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ANERIS

Operational Sensing Life Technologies for Marine Ecosystems

Deliverable D3.2: Validated Bio-opt imaging solution (EMUAS)

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Executive summary

This deliverable document describes the development of a low cost camera system named EMUAS (Expandable Multi-imaging Underwater Acquisition System) which is one of the bio-optical imaging technologies of the ANERIS project.

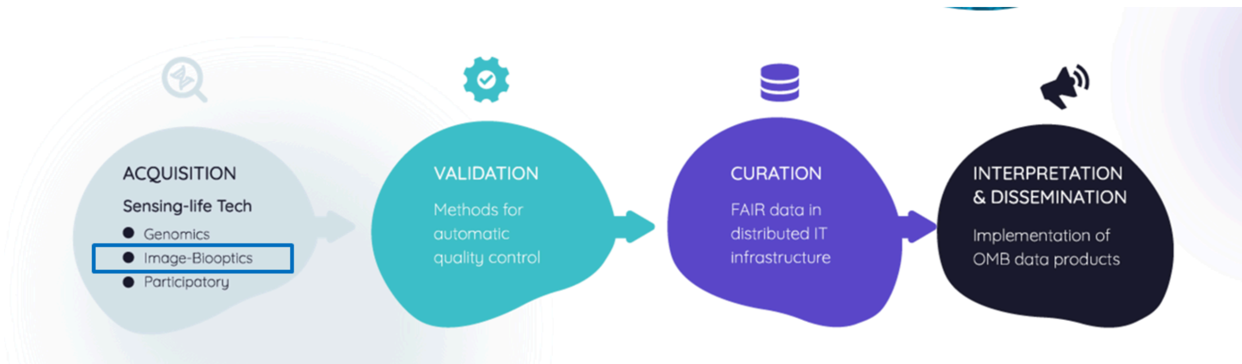

Figure 1: ANERIS project Operational Marine Biology (OMB) Data products based on Image-Biooptics systems.

There is a growing need to improve real-time marine imaging systems to enable the development of innovative Operational Marine Biology (OMB) products.

ANERIS wil address this need by developing and demonstrating a new type of cost-effective cabled multi camera for underwater observatories that can be used independently, or integrated into existing Research Infrastructures (RIs), expanding their capabilities. The multi camera systems will use commercial off-the-shelf components and can be placed within a few hundred meters of shore (or on an existing cabled observatory).

A series of prototypes have been developed during the first two years of the ANERIS project. One critical factor in enabling the creation of long-term, persistent, image-based OMB data products is addressing the impact of biofouling on camera systems. Different low-cost anti-biofouling solutions such as a magnetically coupled mechanical wiper and an external UV-C diode were implemented and evaluated during short experiments. After considering experimental results and long term robustness of the solutions a final anti-biofouling system based on an internal UV-C diode placed on the interior of the camera housing has been developed.

Two EMUAS cameras have been deployed at UPC OBSEA cabled observatory in Barcelona, and current work is focused on integrating the cameras with other ANERIS technologies and the generation of OMB data products.

List of Abbreviations

AIES-MAC – Automatic Information Extraction System for MACro-organisms

AIES-PHY – Automatic Information Extraction System for PHYtoplankton images

AIES-ZOO – Automatic Information Extraction System for ZOOplankton images

AMAMER – Advanced multi platform App for Marine lifE Reporting

AMOVALIH – Advanced Marine Observations VALidation-Identification system based on Hybrid intelligence

ATIRES – Automatic underwaTer Image REstoration System

AWIMAR – Adaptive Web Interfaces for MARine life reporting, sharing and consulting

EMUAS – Expandable Multi-imaging Underwater Acquisition System

ENVRI – Environmental Research Infrastructures

FAIR – Findable, Accessible, Interoperable, and Reusable

KER – Key Exploitable Result

MARGENODAT – workflows for the MARine GENOmics DAta managemenT

MBON – Marine Biodiversity Observation Network

NANOMICS – NAnopore sequeNcing for Operational Marine genomICS

OMB – Operational Marine Biology

RI – Research Infrastructure

1. Background and introduction

1.1 EMUAS

One of the objectives of ANERIS project is the development and demonstration of a new type of low-cost cabled underwater camera observatory, which can augment existing research infrastructure capabilities with limited additional cost and resources. Inspired by the PlasPi marine camera introduced in (Purser et al., 2020), the project aims to develop the concept further by providing a simple real time connectivity, and biofouling mitigation system.

Cabled underwater observatories have typically a high installation and operation cost. When installed far from the coast and in deep locations it is necessary to connect the observatory with costly underwater cables able to provide enough power and communication bandwidth over long distances. Maintenance operations may also have a high cost due to the necessity of using divers, remotely operated vehicles, and support vessels. The ANERIS project aims at research, development, and demonstration of innovative sensors and instruments that allow the implementation of operational marine biology best practices. There is a large amount of valuable information in coastal and shallow areas that could be much easier to operationalize with the use of low cost technologies. The project aims to demonstrate a network of low-cost cameras that are located within reach of coast/land area, where a surface station with power and wireless communication can provide easy access to the data acquired by the cameras. The cameras can be also connected to a small surface box (pelican case) which contains a 5G wifi router, and connection to land power, or alternatively solar panels and batteries.

The box could also be equipped with a small processing unit, such as an NVIDIA Jetson Nano, to provide edge computing functionalities. Automatic event detection could be implemented locally to minimize the amount of video data being transmitted.

Cameras' data could then be made available to other project partners where AI methods are used to automatically detect, classify, and index marine life. Data could be also distributed openly to the general public to help raise awareness over environmental conditions where the cameras are located.

Biofouling mitigation is of utmost importance, and the project will explore simple and affordable methods such as servo-motor actuated mechanical wipers and UV-C irradiation.

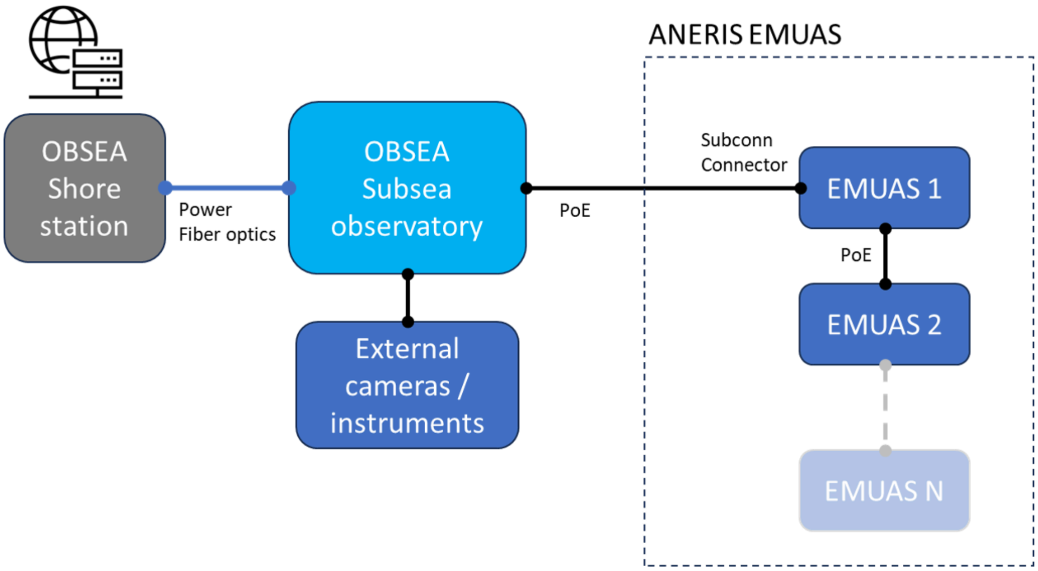

Figure 2: EMUAS system integrated into existing cabled observatory RI

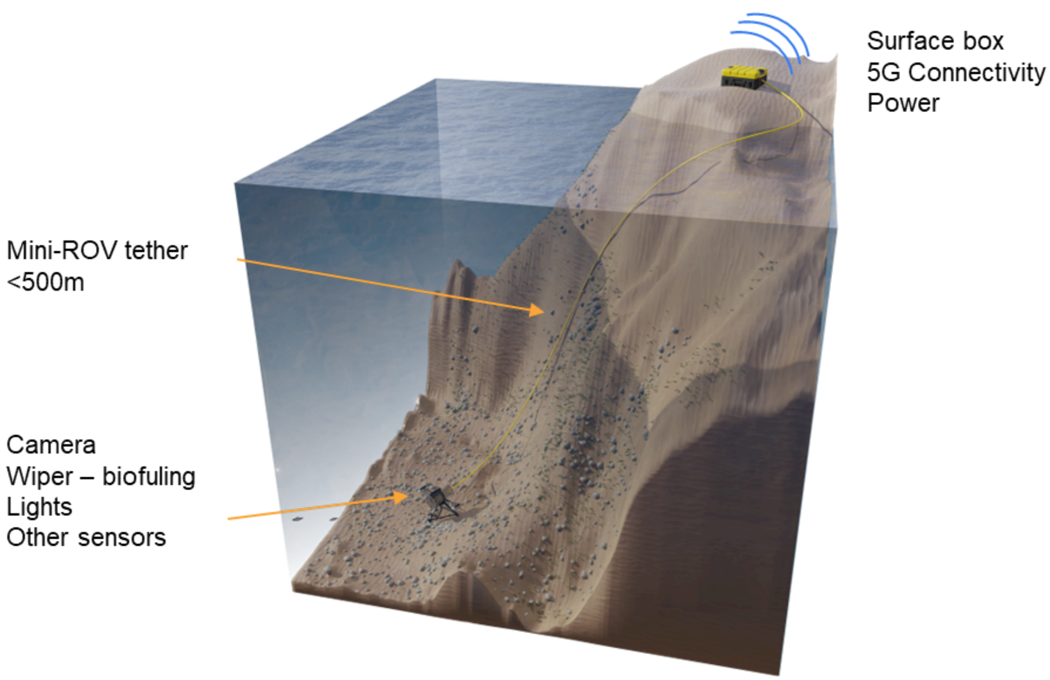

Figure 3: EMUAS system in stand-alone configuration

1.2 EMSO Cabled observatories in ANERIS

There are two EMSO (European Multidisciplinary Seafloor and water column Observatory) research infrastructures that participate in ANERIS project and where project technologies will be demonstrated.

1.2.1 OBSEA cabled observatory

The OBSEA is an underwater cabled observatory located 4 km off the coast of Vilanova i la Geltrú, Spain, at a depth of 20 meters in the Mediterranean Sea. Operated by the group SARTI from Universitat Politècnica de Catalunya (UPC), OBSEA serves as a multidisciplinary research platform designed for real-time monitoring of marine environments. Its proximity to the shore and integration into global marine research initiatives make it a unique and essential node for scientific and technological developments in ocean observation.

OBSEA is a versatile marine observatory supporting research in various disciplines, including marine biology, oceanography, and underwater technology. The observatory is cabled to shore, ensuring a continuous power supply and high-bandwidth data transfer, enabling real-time monitoring and experimentation. Since its deployment in 2009, OBSEA has supported numerous research projects, educational initiatives, and technology tests, cementing its role as a cornerstone of Mediterranean marine research infrastructure. The observatory is equipped with a range of cutting-edge instruments to monitor the marine environment, including:

- **Multisensor nodes**: Recording physical, chemical, and biological parameters such as temperature, salinity, dissolved oxygen, and pH.
- **Hydrophones**: Capturing underwater acoustic data for ecological studies and human impact assessment.
- **Cameras**: Providing live video for visual monitoring of marine life and substrate conditions.
- **Seismometers**: Measuring seabed movements to contribute to geophysical research.
- **Water quality sensors**: Tracking environmental changes and pollution levels.

These instruments are complemented by modular interfaces, allowing integration of new sensors and tools for technology validation and experimental deployments.

OBSEA's architecture comprises a cabled network extending from the shore to the seafloor node, which serves as the central hub for the connected instruments. The robust subsea cables ensure uninterrupted power delivery and data exchange, a significant advantage over autonomous battery-powered systems. This architecture allows OBSEA to operate continuously, offering real-time data streams to researchers worldwide.

Initially conceived as a testbed for underwater instrumentation, OBSEA has evolved into a critical asset for multidisciplinary research and technological development. Over the years, the observatory has supported research on marine ecosystems, underwater noise pollution, and sensor technology innovations.

OBSEA is part of several international research infrastructures and projects, including:

EMSO (European Multidisciplinary Seafloor and Water Column Observatory): OBSEA contributes to EMSO's mission of advancing understanding of the deep-sea environment and its impact on ecosystems and human activities. As a node in this distributed infrastructure, OBSEA plays a pivotal role in observing shallow marine systems and testing novel methodologies.

JERICO (Joint European Research Infrastructure of Coastal Observatories): OBSEA supports JERICO's objectives to enhance and coordinate coastal observatory networks across Europe. Its contributions include long-term environmental monitoring and technology validation.

Local and regional collaborations: OBSEA also partners with Spanish and Mediterranean initiatives to address local environmental challenges and support marine ecosystem preservation.

Through these affiliations, OBSEA integrates into the global effort to establish interoperable, long-term marine observatories and promote sustainable ocean research.

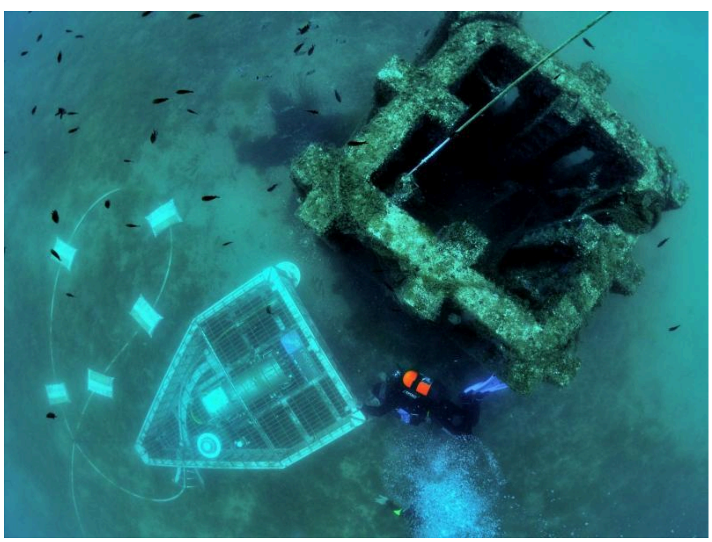

Figure 4: UPC OBSEA cabled observatory

1.2.2 SmartBay

The SmartBay Test Site is located off the north shore of Galway Bay, 2.4 km southeast of the village of Spiddal. The test site is 37 hectares in size with water depths of 21-24 meters and is clearly marked by four cardinal marks, one at each corner. The test site has been in operation since 2006 and forms an intrinsic part of the Government's ocean energy programme. It is a collaborative effort between the Sustainable Energy Authority of Ireland and the Marine Institute.

The test site allows for the deployment and testing of a wide range of prototype marine renewable energy devices, innovative marine technologies and novel sensors. The test site provides researchers and those involved in developing ocean energy devices with an area in which to safely test and demonstrate quarter-scale prototype marine energy converters and related technologies. A maximum of three marine renewable energy test devices can be deployed at the test site at any time, for a maximum duration of 18 months.

The test site also provides access to the SmartBay Observatory, a national shared marine research, test and demonstration facility installed on the seafloor to catalyse and facilitate the commercial development of cutting-edge marine ICT products and services.

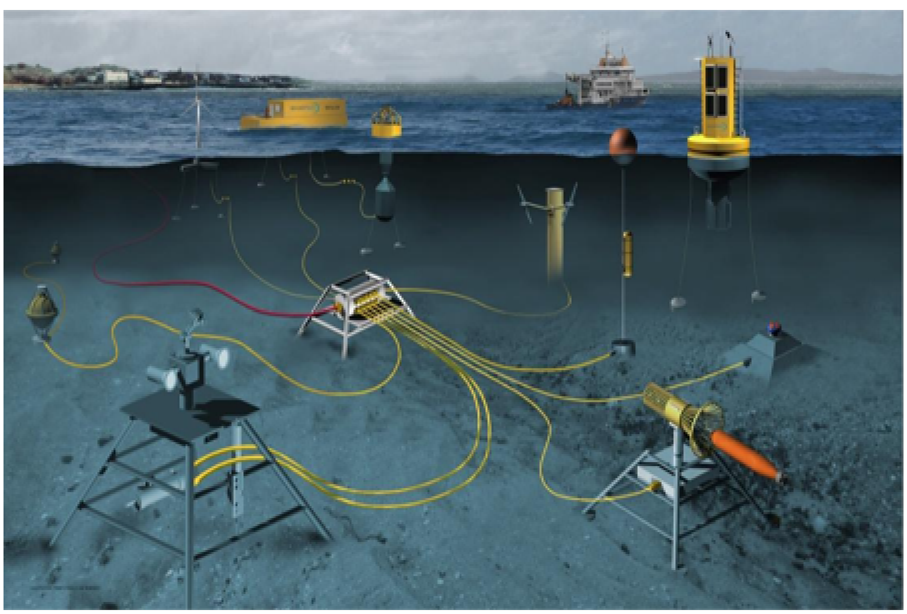

Figure 5: SmartBay Test site

1.3 Biofouling and its impact on long term camera deployments

In the general public's knowledge, biofouling is normally understood as the attachment of algae to surfaces underwater. In reality, there are two components in the formation of biofouling. The first one is called biofilm, or microfouling, while the second one is called macrofouling. Macrofouling is the part that is commonly understood as biofouling.

The biofouling process happens in multiple stages as depicted in Figure Timeline of biofouling process (Shan & JiaDao, 2010)[1].

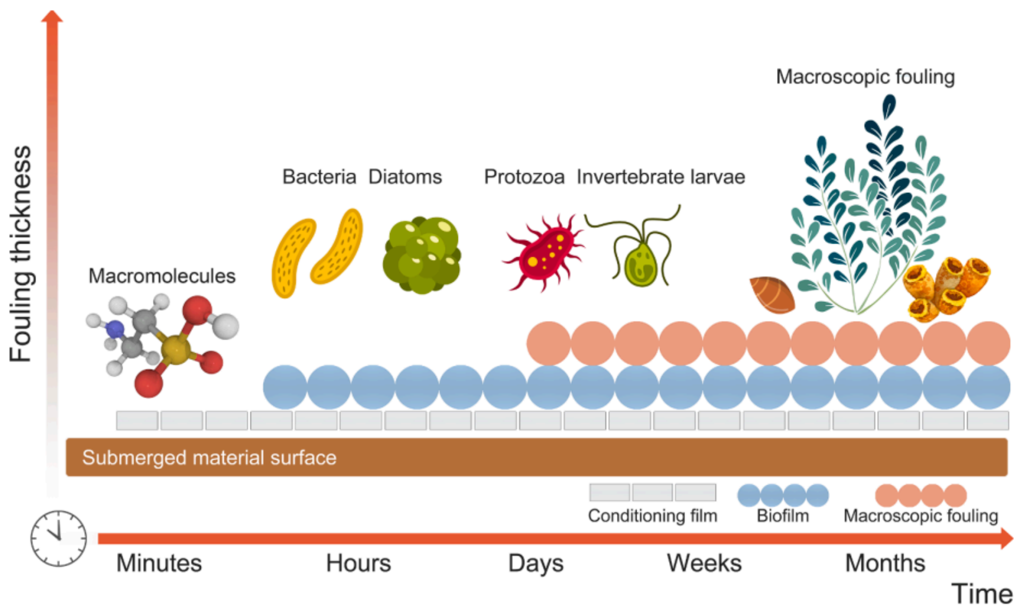

Figure 6: Timeline of biofouling process (Shan & JiaDao, 2010)

Protecting marine sensors from biofouling is crucial because it can impair the sensor's accuracy and functionality by obstructing their surfaces and interfering with data collection. Additionally, biofouling can lead to increased maintenance costs and a reduced operational lifespan of the sensors. It is therefore important to protect the sensors from biofouling and doing it in an environmentally friendly way without damaging the ecosystems.

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[1] Cao, S., Wang, J., Chen, H. *et al.* Progress of marine biofouling and antifouling technologies. *Chin. Sci. Bull.* **56**, 598–612 (2011). https://doi.org/10.1007/s11434-010-4158-4

A) Wipers

A widely used method to protect sensors from marine overgrowth is the attachment of mechanical wipers to the sensor. Usually, a motor is connected to a wiper arm that scrapes brushes across the measuring surface of the sensors. Common materials for the brushes are nylon wires or sponges.

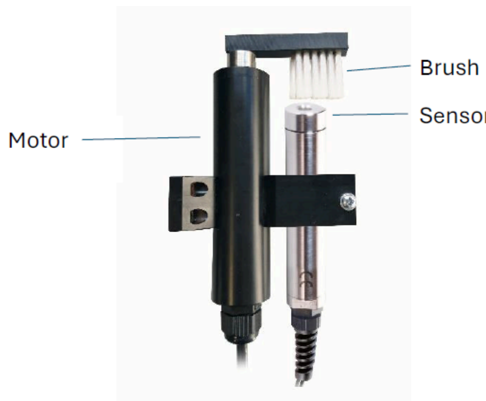

Figure 7: Bell Flow Systems Ltd. Hdyroclean_P Wiper

Wipers have the benefit that they do not affect the environment around the sensors. On the other hand, they require a power supply, which can be critical when the measurements are far from land. Additionally, the brushes themselves are not biofouling-proof and therefore need regular replacement to keep them effective. It is also necessary to mention that while this method of anti-biofouling is successful with for example acoustic or temperature sensors, the brushes can also scratch the surface of optical sensors like camera lenses. Mechanical wipers have some drawbacks that limit their suitability for long term deployments. Moving parts, additional complexity, and the fact that wiper itself is subject to biofouling and may damage camera surfaces reduces their applicability.

B) Biocide solutions

Biocides combat biofouling by inhibiting the growth and reproduction of microorganisms, thereby preventing the formation of a biofilm. Without the biofilm, algae and other organisms are not able to attach to the surface. There are multiple variations to biocide systems. The most popular one is biocide leaching paints usually found on boats or large structures like piers. With solutions like tributyl tin leaching paints being banned due to environmental reasons, most paints today are based on copper. There are two types of biocide paints. The first works by slowly dissolving and leaching cuprous oxide into the area surrounding the covered surface. The second method uses ablative paints that provide a continuously toxic surface. The dissolving tablets are made of bromine and are placed in a perforated container next to the sensor. Over time they consistently leach the bromine into the water surrounding the sensor to protect it from biofouling. While anti biofouling paints are effective for surfaces, they are less useful for optical sensors since a paint would obstruct the view through the lens. They can still be used to cover the non-measuring parts of the device to keep the rest of the device clean.

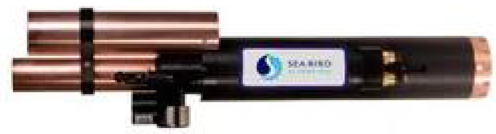

Figure 8: Bleach injection system SEA BIRD

C) UV-C Irradiation

Ultraviolet light type C (UV-C) irradiation is mostly known from medical or food processing environments where it is used to sterilise the equipment. The disinfecting qualities however can also be applied to prevent biofouling. UV-C light wavelengths are in the range from 100nm to 300nm and carry thereby the highest energy compared to UV A and UV B. Once UV-C light shines onto microorganisms, it is absorbed on a cellular level. This leads to a chemical reaction after which the microorganisms are not able to multiply anymore. Hence preventing the formation of a biofouling film that leads to macrofouling (Ryan, Turkmen, & Benson, 2020)[2]

UV-C irradiation has the advantage that it is harmless to the environment around the sensor since no chemicals are leaching into the environment. A UV-C diode is also less energy-consuming than for example an electrolysis setup or motors powering a wiper. It must be mentioned that a UV-C device can only prevent biofouling on a molecular level. If the water is too murky or if debris like sand or drifting algae gets in front of the lens the biofouling device might not be effective (Delgado, Briciu-Burghina, & Regan, 2021)[3].

An off-the-shelf product for UV-C-based biofouling is the AML Oceanographic "Cabled UV Antifouling" solution. The device is a standalone solution that can be added to any type of sensor where it emits UV-C light onto the measuring area. It does not come with a form of debris protection. This is the commercial product that has been used in other ANERIS deployments for a UVP-6 instrument[4].

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[2] Emmet Ryan, Serkan Turkmen, Simon Benson, An Investigation into the application and practical use of (UV) ultraviolet light technology for marine antifouling, Ocean Engineering, Volume 216, 2020

[3] Delgado A, Briciu-Burghina C, Regan F. Antifouling Strategies for Sensors Used in Water Monitoring: Review and Future Perspectives. *Sensors*. 2021; 21(2):389

[4] https://aneris.eu/news/deployment-uvp6-vision-profiler-obsea-seafloor-observatory

Figure 9: AML Oceanographic Cabeled UV Antifouling solution.

The cost of the commercial AML cabled UV Antifouling is considerable compared to the total cost of the EMUAS system. It also requires an additional Subconn bulkhead connector on the camera housing. For this reason a different approach employing an internal UV-C diode inside the camera housing together with a custom made quartz glass end cap has been integrated in the EMUAS system.

2. EMUAS System architecture

There are currently two prototypes, one with an internal UltraViolet-C radiation biofouling solution, and one with an external solution. With the exception of the positioning of the biofouling solution the prototypes are functionally equivalent. The earliest prototype employed a mechanical wiper, however, with limited success and multiple potential failure points that can be eliminated by using UV-C instead

Initial prototypes employed a Raspberry Pi camera module, but this has later been replaced by a 4K IP camera which provides better image quality, and simpler integration and configuration.

Figure 10: Linovision 4K IP camera used in latest EMUAS prototypes. The casing and IR light were removed before installation in camera housing.

2.1 General camera architecture

The camera architecture is designed to be scalable, and easily reproducible. It consists of several key components, including an underwater electronics enclosure housing core components such as the 4k camera, a Raspberry Pi 5 as the main computing board, a Teltonika RUT300 Router for communications, and a UV-C diode to combat biofouling. These components communicate with the surface/cabled observatory via a tethered ethernet cable, which links the underwater system to a central hub and provides data connection and power. Each enclosure is capable of daisy chaining at least one additional enclosure to the first.

In a stand alone configuration, the central hub serves as the primary data processing and transmission center, making all collected data openly accessible via the internet, both through live streams via youtube, and by uploading 15-minute clips to an online server to be made available for download.

Figure 11: Teltonika RUT300 used in the EMUAS camera housing

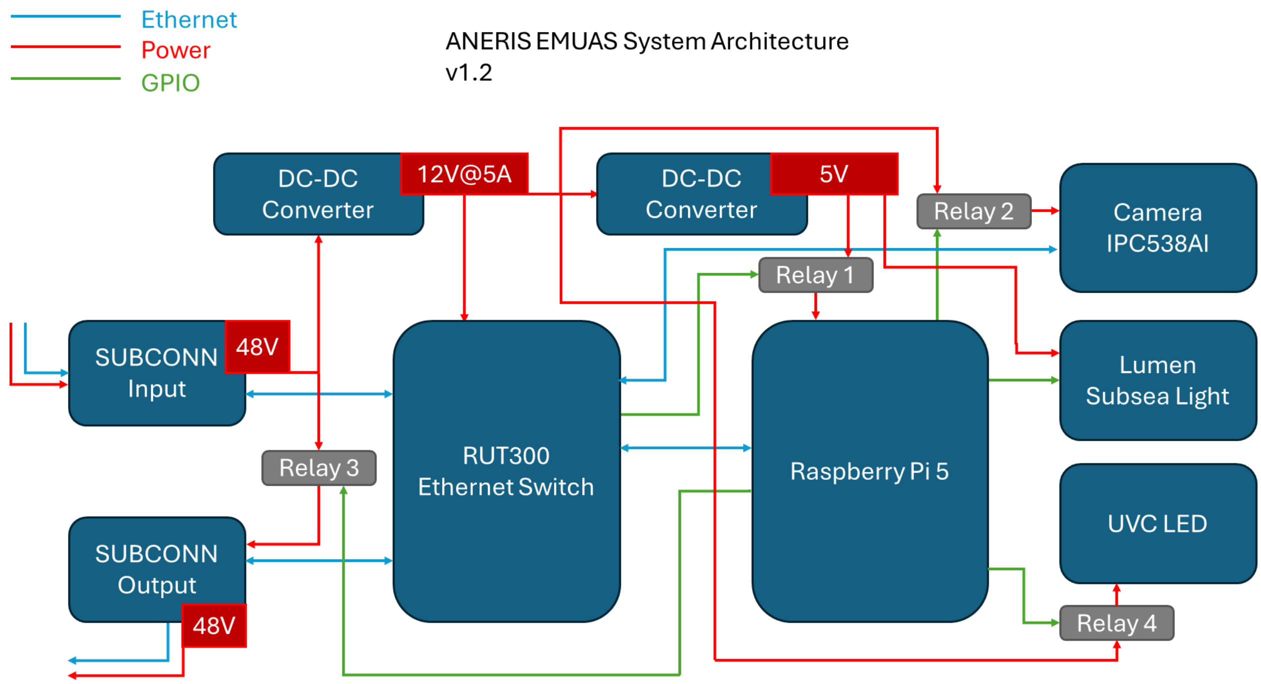
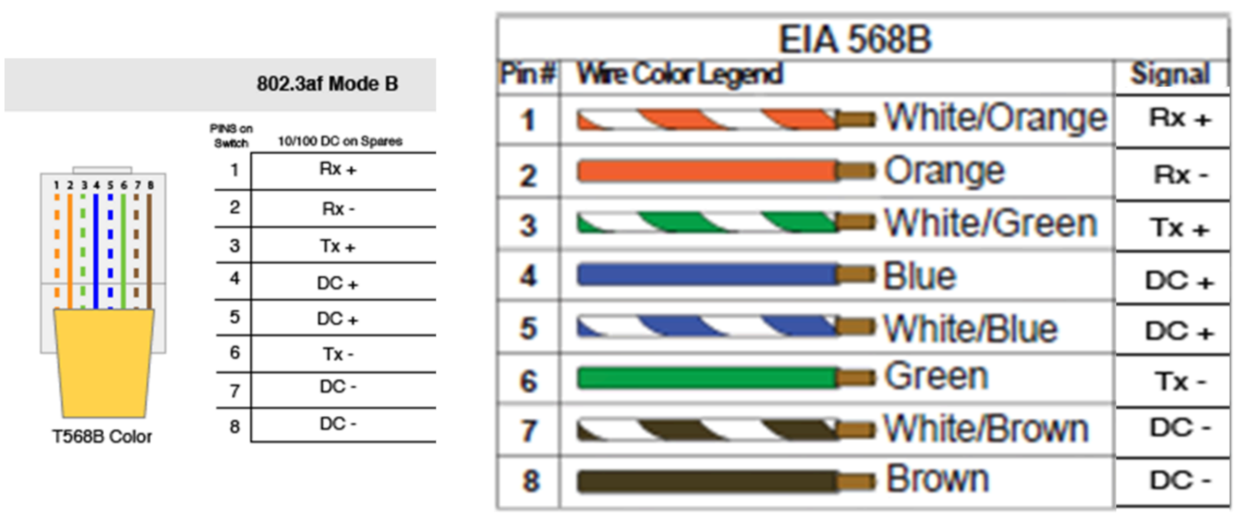


Figure 12: General EMUAS architecture as deployed in OBSEA



802.3af Mode B	
PINS on Switch	10/100 DC on Spares
1	Rx +
2	Rx -
3	Tx +
4	DC +
5	DC +
6	Tx -
7	DC -
8	DC -

EIA 568B		
Pin#	Wire Color Legend	Signal
1	White/Orange	Rx +
2	Orange	Rx -
3	White/Green	Tx +
4	Blue	DC +
5	White/Blue	DC +
6	Green	Tx -
7	White/Brown	DC -
8	Brown	DC -

Figure 13: Standard wiring for PoE used internally in camera housing

	SubConn 8 Eth Aneris	
pin	Color	Function
1	Brown	Tx+
2	Wh/Bro wn	Tx-
3	Blue	Rx+
4	Wh/Blue	Rx-
5	Orange	DC-
6	Wh/Ora nge	DC+
7	Green	DC-
8	Wh/Gree n	N/C

Figure 14: EMUAS camera connector pinout - Note that this is not standard PoE pinout and it is used for compatibility with other already installed instruments at OBSEA

2.2 Stand-Alone Version

The stand-alone camera system is a simplified version of the primary EMUAS system. It comprises only the camera unit housed within an underwater enclosure, while all other electronics are contained in a watertight Pelican case connected by a tether cable on land. It is equipped with a Teltonika RUT 241 wireless router to enable wireless internet connectivity, though the Pelican case can be connected to a LAN via an Ethernet cable for connectivity purposes. The system can be powered through a standard wall socket.

Figure 15: Initial Linovision standalone camera system, without antifouling system

Initial tests using a Linovision 4K underwater camera were promising, however after 3 months of deployment with intermittent drops in connection, two camera systems showed complete failure, with shorts occurring within the camera housing, these systems do not seem to be designed with long term submersion in mind.

2.3 Camera housing

The camera and electronics are housed inside an anodized aluminium BlueRobotics cylindrical enclosure of dimensions 100mm x 400mm. These enclosures are rated to a depth of 750m. The standard acrylic flat end cap has been replaced by a custom made quartz glass which is transparent to UV-C radiation.

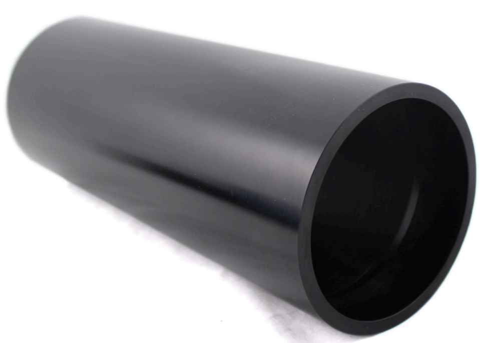


Figure 16: Blue robotics aluminium housing used in EMUAS

2.4 Frame

Two main methods have been used for frame construction so far, and the frame is a very flexible component that can be modified to suit the conditions of the deployment area. For all testing performed in and around Oslo, Norway, an anodized aluminium extruded profile frame was used. These can be bought in packs from producers such as RatRig and come with screws and connectors for relatively simple assembly. The extruded profile provides ample area for external attachment of lights, sensors and ballast weights and are inexpensive. A potential drawback of this frame is the corrosiveness of aluminium in saltwater, though the anodization of the profiles does reduce this effect and no serious structural issues have been encountered so far even without the use of a sacrificial anode.

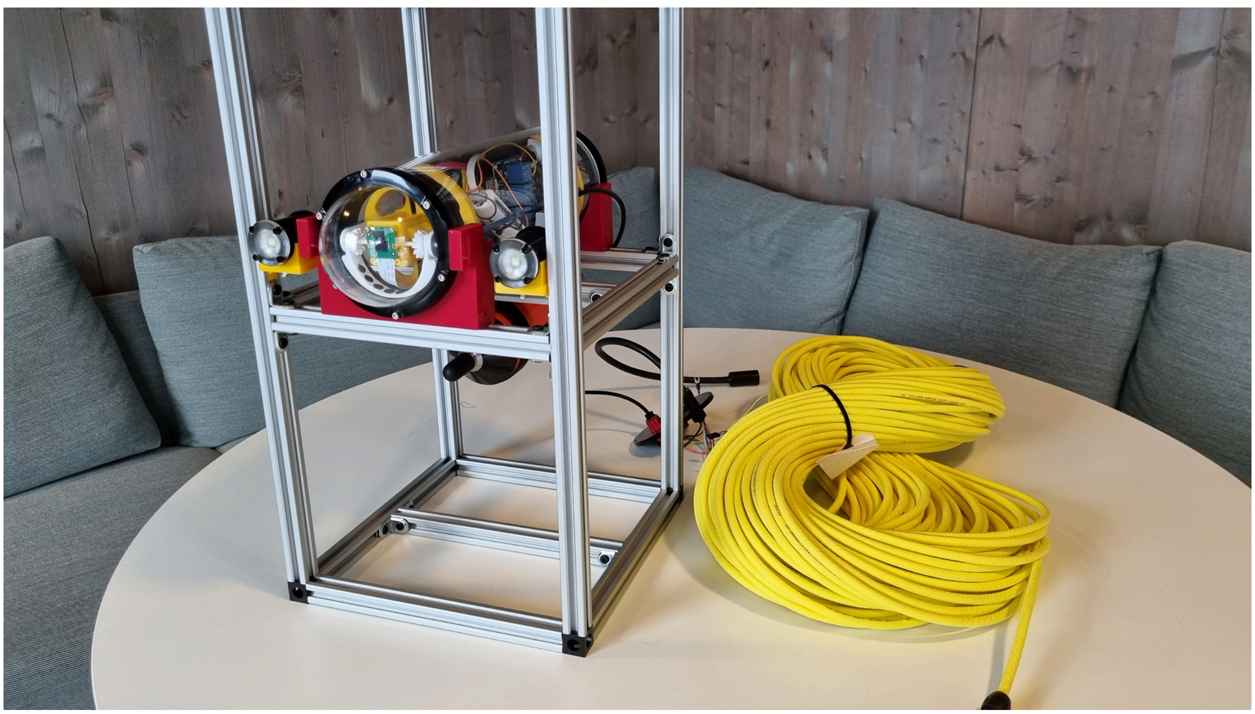


Figure 17: EMUAS extruded aluminium frame example, later versions are anodized for added protection as can be seen by the black frame color in some later images.

The second method was developed by the Universitat Politècnica de Catalunya (UPC) - Sarti group to align with the Research Infrastructure (RI) currently deployed off the coast of Villanova, Catalonia. This design uses a stainless steel frame that fits within the existing slots on the RI and is secured with zip ties, providing adequate support. However, attaching external lights or sensors can be challenging because it requires the design of custom attachment points on the frame, unlike the modular flexibility of the aluminium frame.

Despite this, the frame is highly customizable, provided the appropriate tools and metalworking skills are available.

Figure 18: EMUAS OBSEA frame example

2.5 Power and data

Both power and internet are delivered over the same cable, a UTP, 4-pair ethernet cable, wired using the T-568B standard. Power over Ethernet (or PoE) standard 802.3af is used, with the cable used in 10/100 mode and power being delivered over the spare pairs (i.e., connectors 4, 5 deliver DC+, and connectors 7, 8 deliver DC-). The device is passively powered, i.e. the supply is always “hot”, and no communication happens between the device and the supply. The voltage used to power the prototype is within PoE standard (48V), although voltages outside the specification (in the range [18, 70]V) can be used.

This cable can either be connected directly to the backing plate of the enclosure, or to a subconn 8-pin cable, allowing it to separate the cable from the prototype itself.

2.6 External LED lights

Two Blue Robotics ROV lights are mounted to the side of the enclosure, to provide lighting to the surrounding environment in low-brightness situations. These two lights are daisy-chained and connected to a single PWM pin on the Raspberry Pi. This configuration allows them to be turned on and off simultaneously, thereby consuming only one PWM slot.

Figure 19: Blue robotics Lumen LED lights

2.7 Software

The software written is used to turn on and off components as needed, such as the camera, the lights, and the UV-C LED. A web interface is provided to allow remotely changing and testing settings. Flask and uWSGI are used to provide the web server, and to run the code needed to control the state of the Raspberry Pi's GPIO pins.

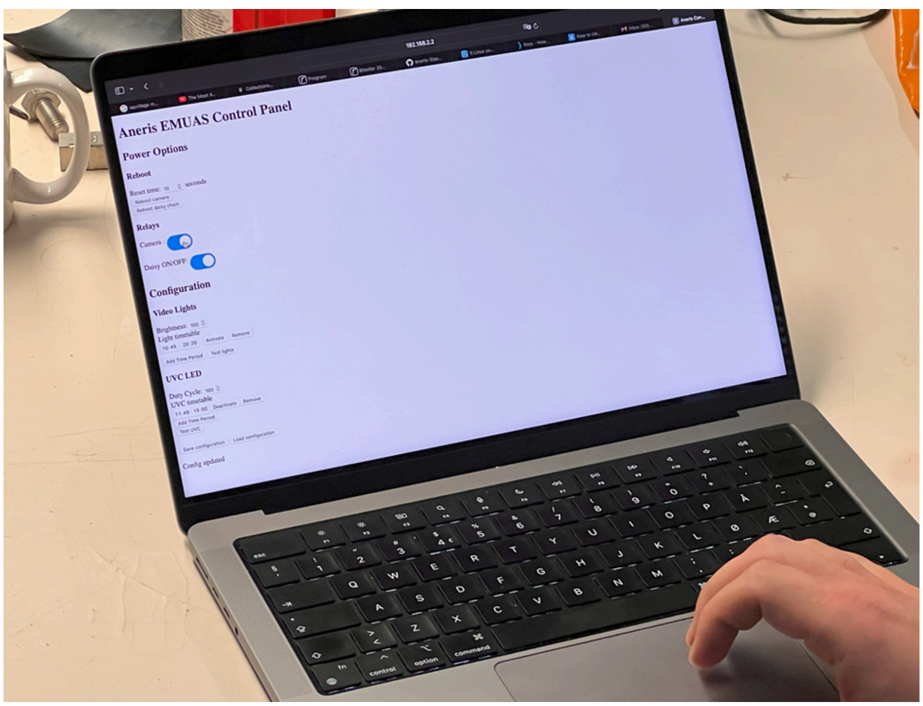


Figure 20: Simple configuration web graphical user interface in development

2.8 Image settings and recording strategy for OBSEA deployment

The camera resolution is set to 1440p for now due to limitations on the RI. Encoding is set to H.264+, locked at 20 frames per second (fps) with a maximum bitrate of 16384. Full image settings are provided in the appendix.

Video is live streamed to Youtube via the top-side PC that the system is tethered to. Every 30 minutes a still image is captured. During night the lights are turned on for a minute prior to the image being taken to illuminate the scene and give the camera as much time to adjust to the light while minimizing interference of the fauna in the area.

2.9 Antifouling mechanical wiper

The earliest prototype of the EMUAS system, built in 2023, which employed a mechanical wiper to periodically wipe the camera viewport to keep it clear of biofouling that may obstruct the camera.

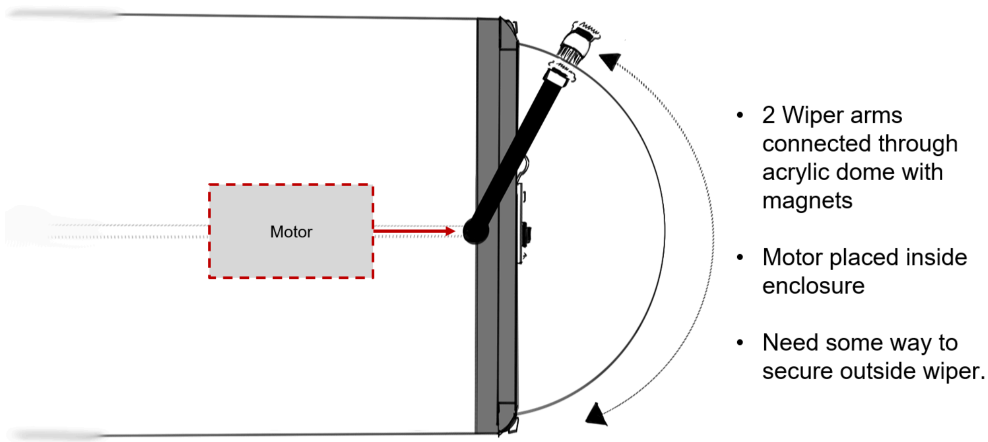


Figure 21: Mechanical wiper anti biofouling early concept.

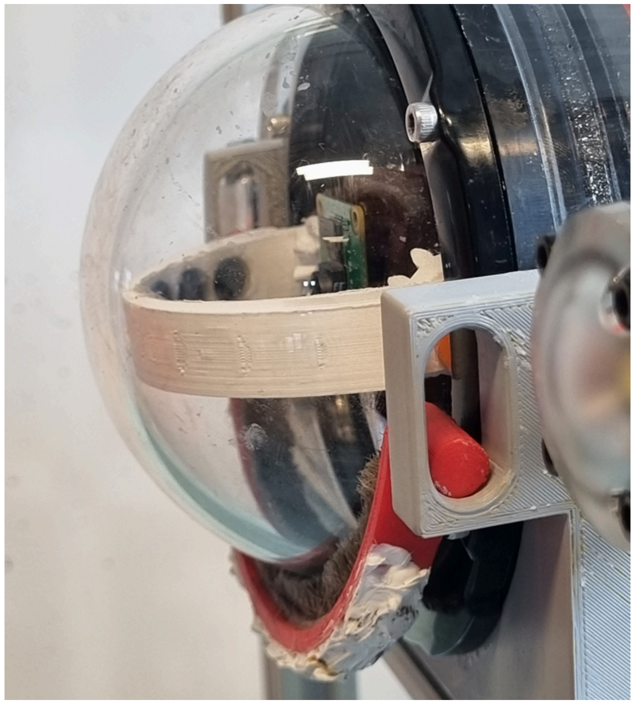


Figure 22: First prototype EMUAS system with mechanical wiper.

A servo housed within the enclosure, behind the camera actuates a semi-circular arm containing 8 neodymium magnets, inside the housing from bottom to top. At each end is a hall sensor that triggers a stop reversal of the actuation until the triggering of the second sensor which stops the wipe process. This is performed once an hour.

Initial testing resulted in a failure after 9 days, after which the 3D-Printed gears and support walls for the internal arm detached, causing the servo to continuously operate until it was discovered through the hydrophone audio on the livestream. While further modifications to the design would likely have corrected the issue, moving from a mechanical solution to an electrical one, eliminated a large number of potential problems later on, and the efficacy of UV-C has been proven, both in previous works, and in commercial/industrial cases.

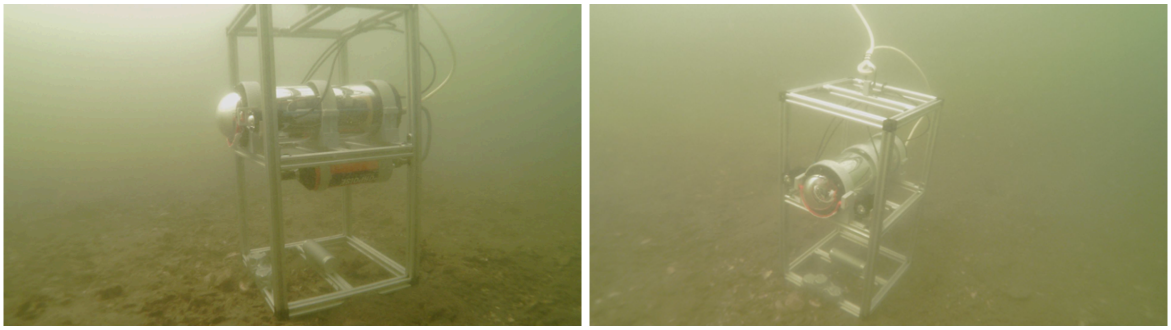


Figure 23: Testing preliminary EMUAS prototype with mechanical wiper in Oslofjord

2.10 Antifouling External UV-C concept

Tests involving an externally mounted UV-C diode coupled with a shroud to prevent dirt and debris from settling on the camera viewport showed promising results with little to no biofouling visible on the viewport. Some concerns were raised on an additional external cable from the enclosure to the diode being a possible point of failure, however this method can be used with existing BlueRobotics (or any other) domed or flat viewport pieces, the majority of which are made with acrylic, a material that attenuates UV-C, preventing it from passing through the camera viewport.

Figure 24: External UV-C anti biofouling system prototype

Figure 25: Testing of EMUAS camera prototype with external UV-C system, recovery after 16 days

2.11 Antifouling internal UV-C

After the success of the external UV-C, investigations into the possibility of affixing the UV-C diode within the enclosure led to the adoption of a custom quartz viewport that is UV-C transparent, allowing the UV-C to perform its anti biofouling role from inside the enclosure. This is the latest EMUAS version as deployed in OBSEA, and the same UV system planned to be used in SmartBay deployment.

The internal UV solution has several advantages. It is cost effective, simple, has no moving parts, no need for additional penetrators/underwater connectors, the UV-C diode is very close to the glass which may increase the efficiency of the system and reduce total power consumption.

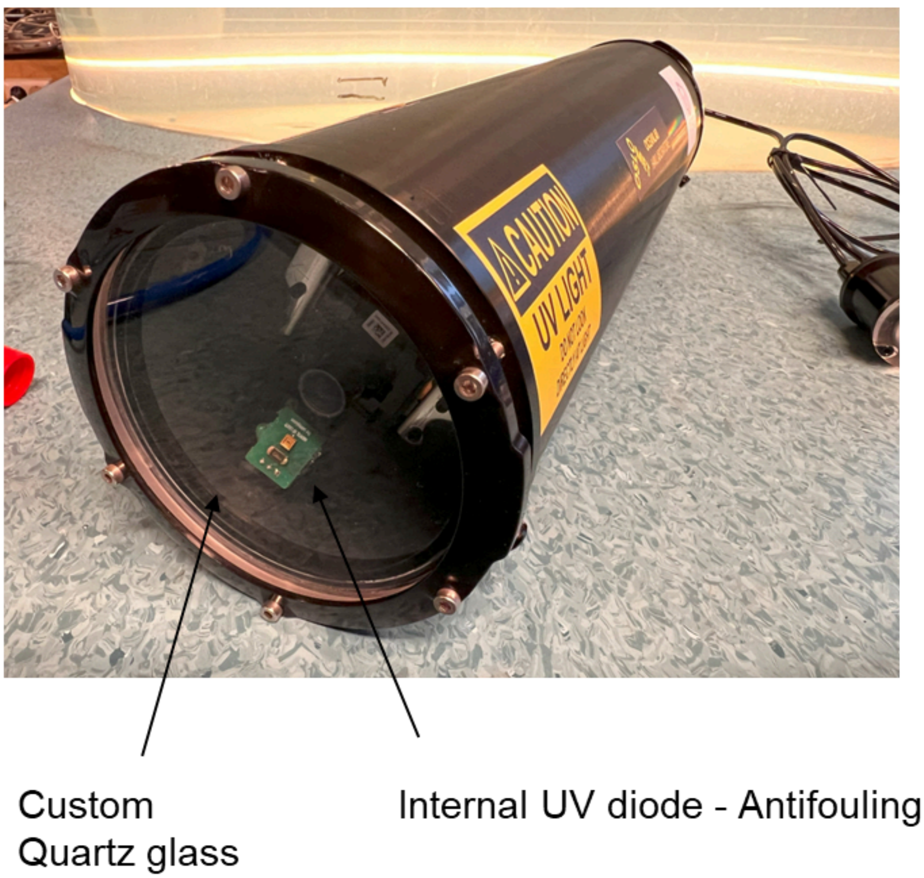


Figure 26: EMUAS camera with internal UV-C anti biofouling system that will be later deployed at OBSEA.

As shown later in section 3.2, preliminary results of the internal UV-C anti biofouling system are promising.

Current version has a limited heat dissipation design, which limits the available duty cycle of the UV system. Future versions will improve this to allow for a greater flexibility in using greater power / longer duty cycles.

2.12 Hydrophone integration

Preliminary work has been done in integrating a low cost hydrophone into the EMUAS system. A low cost hydrophone has limited bandwidth characteristics which limits its ability to identify certain species. Nevertheless the hydrophone signal can have an interesting added value in monitoring man made noise and provides greater public dissemination impact. The audio signal can be streamed live together with video in public platforms such as youtube, providing an additional interest for the general public. Current deployment in OBSEA does not include a hydrophone, but later deployments such as in SmartBay might include one.

Figure 27: H1a Hydrophone low cost hydrophone from Aquarian Audio (left) and low cost usb audio interface.

2.13 Network configuration

As mentioned previously, network access is provided to the device for both streaming and control. A Teltonika RUT300 router is installed as the "core" of the device's network, interacting with both the host network on land, and with other devices within the enclosure. The router is configured to accept a dynamically assigned address on its WAN port, while also acting as a DHCP server. Devices such as the camera and Raspberry Pi are given a static IP address to ensure they remain accessible, even if the router cannot provide an IP address.

The router's firewall is also configured to allow users on the WAN network to access some specific services, namely HTTP access to the camera and Raspberry Pi, SSH access to the Raspberry Pi, and RTSP access to the camera; this is done to allow to easily modify settings and receive the video stream once the device is deployed, without needing to be connected to a VPN server constantly.

Additionally, the network is configured to provide remote access through a VPN. Once internet access is established, the router connects to a cloud OpenVPN server and operates as a Point-to-Site (P2S) VPN, allowing users to remotely interface with all devices on the local network as if connected directly to LAN.

2.14 Streaming settings

A Youtube stream is started for each deployed camera, to allow public access to the camera feed. As the camera's video output is not directly compatible with Youtube's servers, FFMpeg is used to convert the RTSP video to RTMP[5].

[5] https://www.obsea.es/liveVideo/
https://www.youtube.com/@ANERISEMUASOBSEACam2-p4g
https://www.youtube.com/@ANERISEMUASOBSEACam1-e6p

3. Tests and integration

3.1 OsloMet Oceanlab

Different versions of the EMUAS system have been tested in the OsloMet Oceanlab.

A) Havnelangs 2024

Havnelangs is an annual Oslo harbour activity that offers several activities to the general public. During this event almost 200 people visited the OsloMet Oceanlab and could follow a live stream of one EMUAS camera deployed in front of the laboratory.

Figure 28: OsloMet Oceanlab during Havnelangs 2024 and EMUAS live stream shown in a large screen for the general public[6]

[6] https://youtu.be/1D0Jdyxi5gg?si=vh8xa8IKBdgOW3Qn

B) Iliad Hackathon Digital twins of the Ocean

Another test activity include cooperation in the organization of a Hackathon together with EU project Iliad

https://ocean-twin.eu/hackathon-digital-twins-of-the-ocean

Two cameras were deployed during the event, one in an artificial reef in a stand alone configuration, and one in front of Oceanlab. The two cameras were streaming to youtube during the weeks before and after the event.

A group of students and researchers participating in the hackathon implemented artificial intelligence models to automatically identify species in the EMUAS cameras.

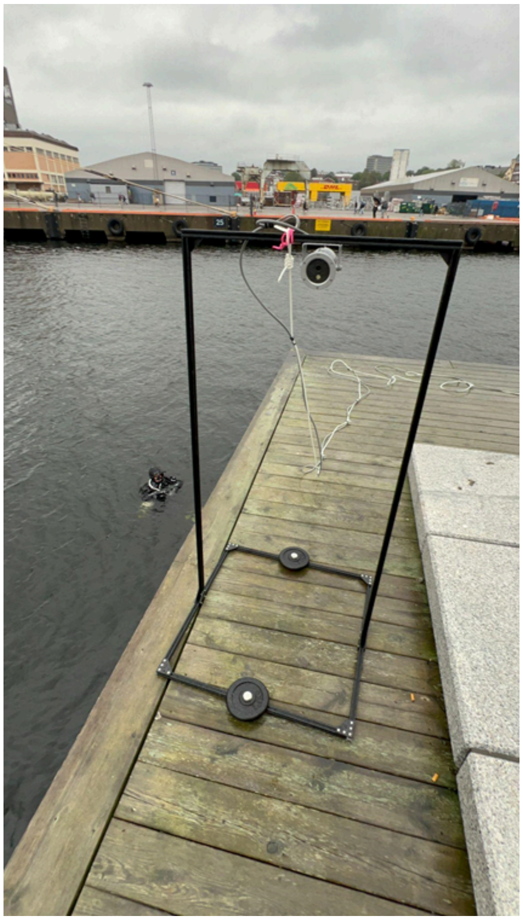


Figure 29: Stand alone camera prior to deployment in artificial reef

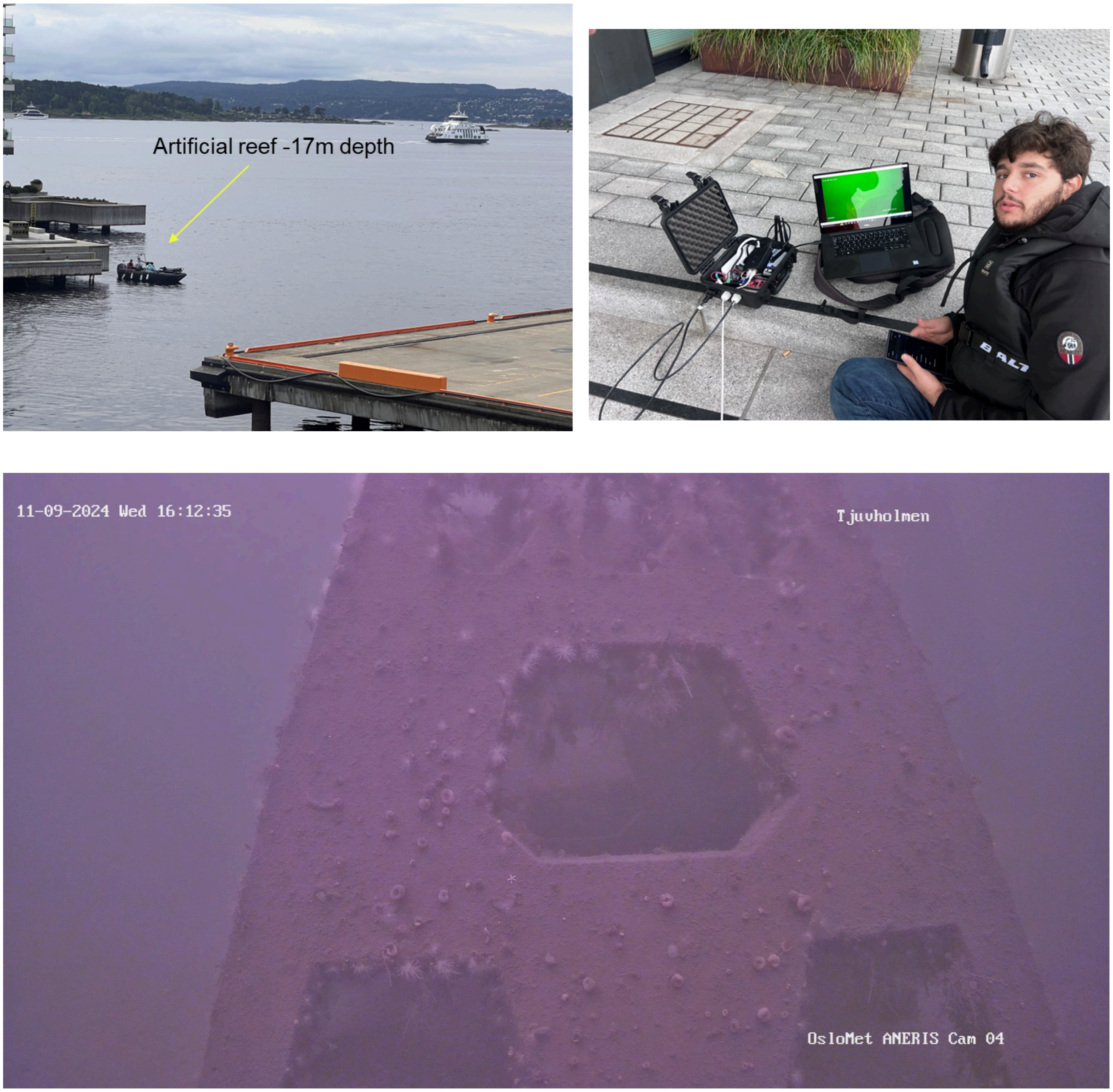


Figure 30: Deployment of EMUAS in artificial reef in stand-alone configuration and Youtube streaming of artificial underwater reef during Hackathon[7]

[7] https://www.youtube.com/watch?v=zsrfL9w8qWc&t=14106s

Figure 31: Iliad Hackathon participants working with EMUAS generated images

Figure 32: Example of results from Hackathon, automatic cod identification[8]

[8] https://www.youtube.com/watch?v=7K54Um8yrfM

3.2 OBSEA Deployment

In November 2024, two systems were deployed and connected to the SARTI OBSEA Research Infrastructure in Spain One main system with internal UV-C anti biofouling measures, and one standalone system which is daisy chained to the first and relies on the primary system to manage all data and power. As mentioned in section 2.4, the frames were built by the SARTI team using stainless steel, contrasting with the anodized extruded aluminium profiles used in Norway.

Results of the antifouling system were clearly visible after several days of deployment, a stark contrast to all deployments in Norway where biofouling was absent for several weeks though this is likely due to increased biological activity in the warmer Mediterranean waters. (Railkin, 2003), (Wahl, 2009)

The daisy chained, standalone system without antifouling measured developed biofouling within 6 days, being significant enough to visibly obscure the camera in 20 days. On the other hand, the main system with antifouling capabilities has shown no sign of biofouling on the camera viewport after 20 days.

Figure 33: Two EMUAS cameras prior to transport to OBSEA

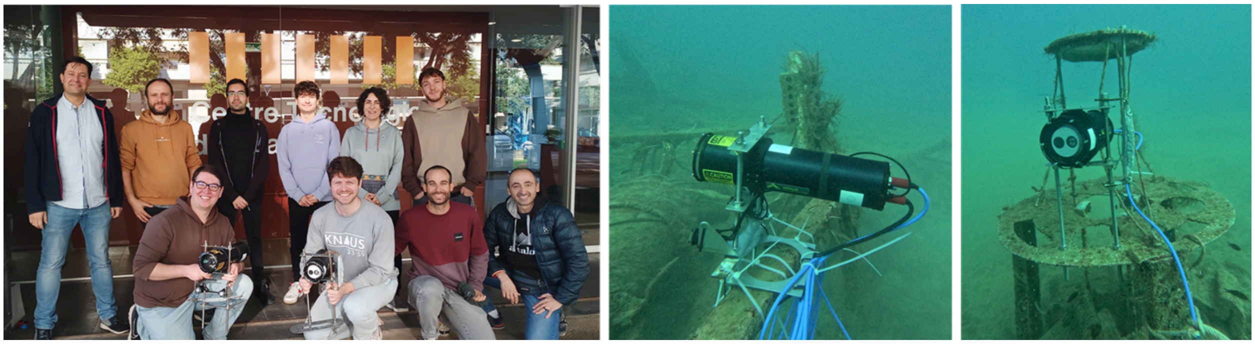


Figure 34: UPC and OsloMet ANERIS team during deployment at OBSEA

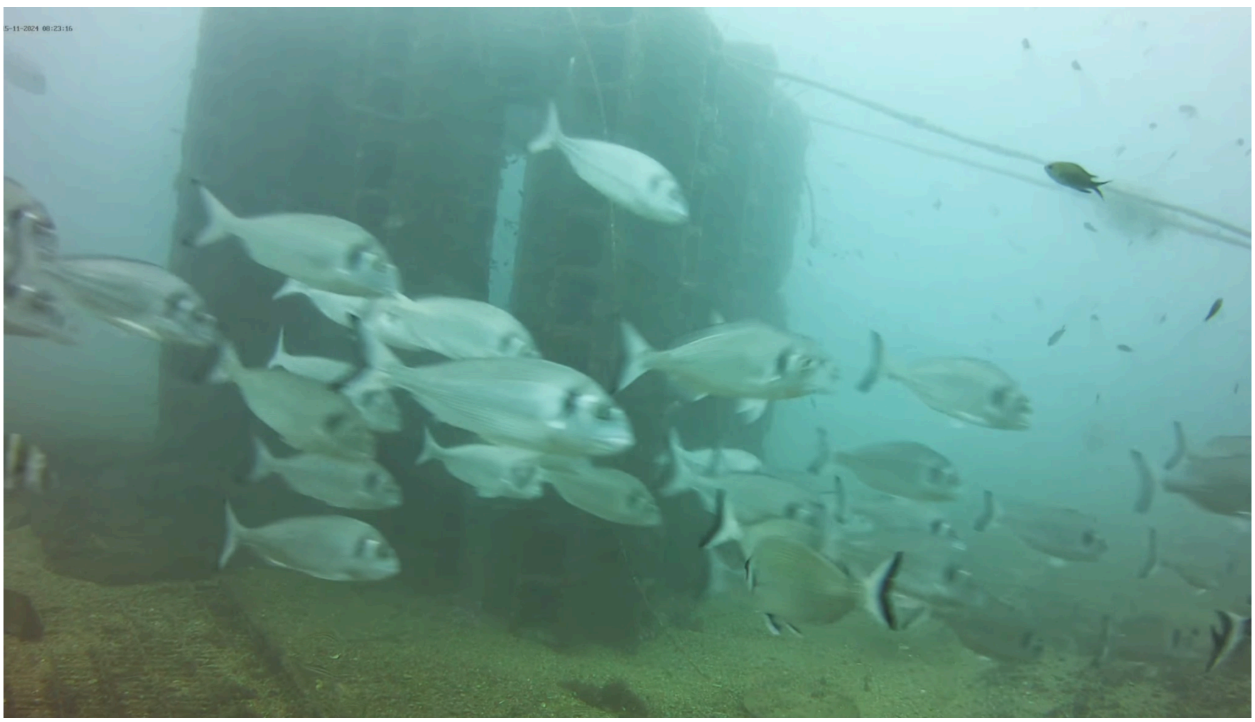


Figure 35: First images obtained from EMUAS Cam 1

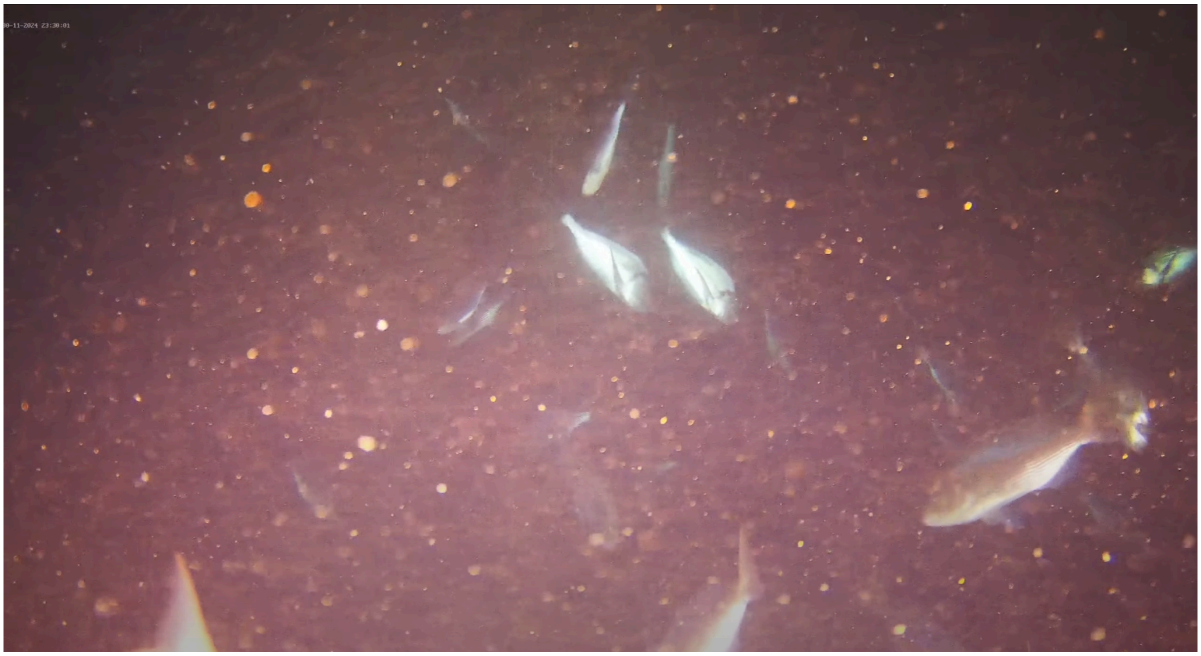
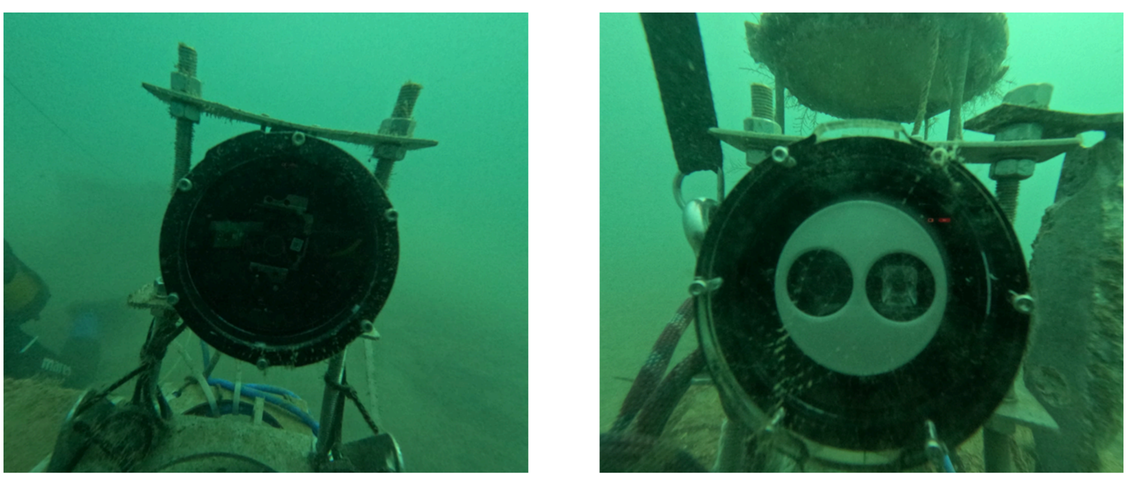


Figure 36: EMUAS Cam 1 night picture. Lights turn on for 1 minute every 30 minutes during night.



Cam 1 with UV Antifouling

Cam 2 without UV Antifouling

Figure 37: EMUAS cameras after 3 weeks of deployment

Figure 38: Comparison of biofouling evolution in EMUAS Cam 2 (left) without UV system, and EMUAS Cam 1 (right) with UV system. Image taken 6, 16, 20, and 26 days after deployment.

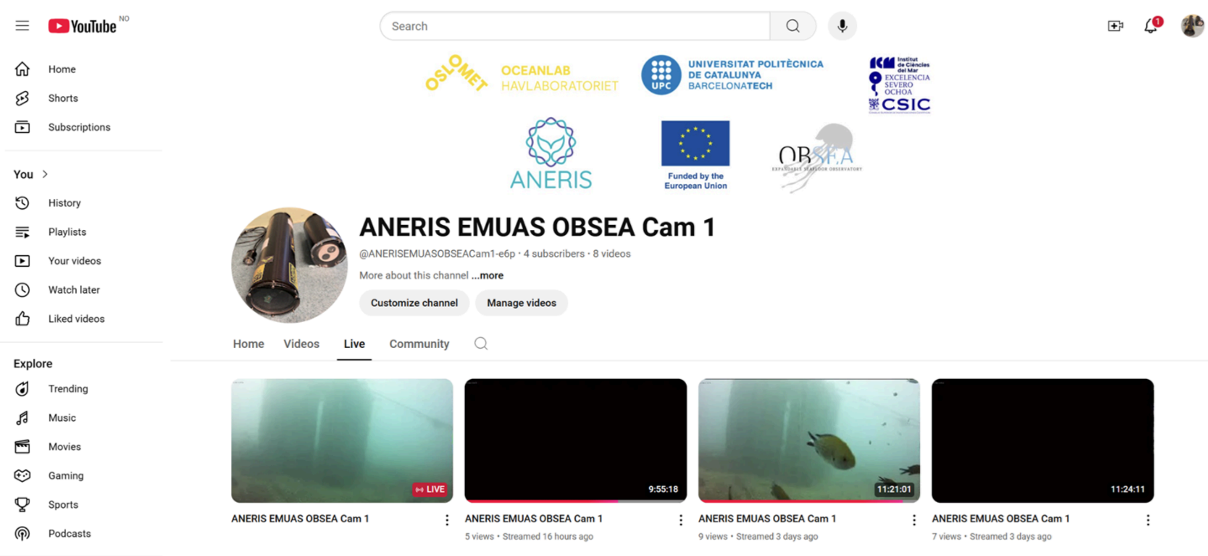


Figure 39: Youtube channel page for EMUAS cam 1 with public live streaming[9]

As a preliminary solution, an image is captured automatically from both cameras and stored in a UPC OBSEA server every minute which is publicly available. Work is being carried out by other ANERIS partners to integrate the data streams with other technologies and make data available through ANERIS data platform.

Index of /pictures/ANERIS_EMUAS_1/2024/11/24/

../		
20241124-000001-ANERIS_EMUAS_1.jpg	24-Nov-2024 00:00	34618
20241124-000013-ANERIS_EMUAS_1.jpg	24-Nov-2024 00:00	34457
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20241124-000047-ANERIS_EMUAS_1.jpg	24-Nov-2024 00:00	31826
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Figure 40: UPC OBSEA public repository of EMUAS images[10]

[9] https://www.youtube.com/live/FviI3eMD_Ec?si=eGUkDkejKf3hPreA
[10] https://files.obsea.es/pictures/ANERIS_EMUAS_1/
https://files.obsea.es/pictures/ANERIS_EMUAS_2/

3.3 Lessons learned and future work

The experiences learned during the prototypes deployed at OBSEA will be used to develop an improved EMUAS version to be deployed at SmartBay in Ireland.

After the OBSEA deployment several key takeaways were made: reducing the quantity of, and securing all loose internal wires will prevent accidental disconnections due to transport, which consumed the majority of day 1 of the 3 day window available for deployment. A liberal application of electrical tape and zip ties would serve as a stopgap solution, but the design and manufacture of a custom PCB to reduce clutter inside the enclosure would be a more concrete long-term solution.

A custom PCB would also serve to reduce the overall form factor of the system which is a secondary goal of further improvement. Reducing the size of the enclosure would improve transportability and make deployment easier. Consolidating all input and output connections on a PCB just behind the backplate of the enclosure would also reduce the difficulty of disassembling the enclosure and reduce the chances of accidental disconnections when attempting to troubleshoot internal components.

Finally implementing an official standard for subconn to ethernet connections would also help to reduce confusion when integrating the cameras to existing RI systems, and mitigate opportunities for miswiring to cause shorts or otherwise disrupt operation.

In terms of expansion of the EMUAS stand-alone configuration, we plan to do a workshop on codesign with Science of Change and possible end users, specially harbors, to try to establish a network of autonomous cameras to obtain continuous data in more areas, contributing to the OMB product.

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