Utilization of Underwater ROVs for the Evaluation and Research of the Underwater Environment -Example of Marine Outfalls Surveillance in the Wider Aquatorium of the City of Split

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Abstract: In recent times, the usage of underwater robots (ROVs or submersibles) has become ever more frequent in the research and monitoring of the aquatic environment. The crucial difference between a submersible regarding unmanned aircraft vehicles (UAVs) is that wireless connection does not function underwater, which is why an ROV must relate to a controller (i.e. remote pilot) by a tether. Like UAVs, underwater robots are equipped with a camera that can take high-resolution photos and video footage, while some models accommodate the usage of exchangeable accessories such as a robotic arm, dead fish removal shovel, mud sampler, water sampler, and similar. When it comes to mid-priced underwater robots for wide use, these can go as deep as one hundred meters with a tether length of two hundred meters which suffices for the conduction of the most common tasks such as recording the aquatic habitats, collecting sediment samples under fish farms, or recording video footage of marine outfalls.

This paper describes the experience of recording video footage of marine outfalls in the wider aquatorium of the city of Split by using the underwater robots QySea Fifish V6 Expert and QySea Fifish V-EVO, and auxiliary equipment.

Keywords: underwater research; underwater robots (submersibles); underwater footage.

1 Introduction

When talking about close-range remote sensing, one usually refers to UAVs (unmanned aerial vehicles) or, to put it more precisely, UASs (unmanned aerial systems), because the whole equipment consists of a vehicle (drone), remote controller, and the remote pilot. UASs have been thoroughly described and researched and there are many articles regarding their utilization and application. However, underwater robots or ROVs are a much more recent phenomenon that yet must find its niche in the close-range remote sensing of the underwater environment. Nevertheless, there are articles on ROVs utilization for various underwater research purposes dating as far back as 2012 (Andaloro et al. 2012) which deal with assessing the suitability of ROVs to study fish communities associated with offshore gas platforms in the Ionian Sea, or more recent research by Sward, Monk and Barrett (2019) which gives more general research on the use of ROVs for visual assessment of fish assemblages, and broad research of McLean et al. (2020) on enhancing the scientific value of ROVs in the oceans.

Affordable and widely available ROVs can perform tasks like exploring hard-to-reach areas, data collection, sampling, inspection, maintenance, scientific research, search and rescue, and environmental monitoring. Unlike UAVs, operating ROVs has minimal legal requirements - no piloting license is needed, only consent from the relevant ministry for recording marine habitats, underwater life, or anything beneath the sea surface, as per the Maritime Act (Official Gazette of the Republic of Croatia 2020).

This paper describes recording underwater footage of marine outfall pipes around Split. Using ROVs for this task is much cheaper and faster than traditional methods involving divers, sea scooters, and head cameras.

2 Materials and methods

The recording of Split's marine outfalls was conducted from September to November 2023 using a fast rubber boat, a QySea Fifish V6 Expert and V-Evo ROVs (Figure 1) with an Eco Flow portable power station, a high-luminosity tablet, and a cell phone for outdoor positioning (using the QField app).

Figure 1. The equipment comprised one QySea Fifish V6 Expert (top) and one QySea Fifish V-EVO ROV (bottom).

Before starting, we analyzed the number of outfalls, their length, and the depth of discharge points relative to the ROVs' capabilities (Figure 2). With the ROVs' maximum depth at 100 meters and the deepest discharge point at 60 meters, we determined the ROVs were suitable for the task. However, we did not initially account for challenges like sea currents, weather conditions, and significant turbidity caused by silty sediment in this part of the Adriatic.

Figure 2. Marine Outfalls in the wider aquatorium of Split. The first number is the length of the pipe, and the second is the depth of the discharge point (expressed in meters).

The equipment used comprised two ROVs which were used interchangeably (while one was operating, the other one was charging), an EcoFlow Delta 2 portable power station with 1 kWh capacity and an 1800 W output, a high-luminosity tablet required for monitoring of an ROV performance and a cellphone with QField application in which all outfalls and discharge points were added and which was used to navigate and find areas of interest on the sea. And, of course, a fast 8-meter rubber boat equipped with a powerful engine provided for fast movement between the outfalls.

The key difference between an ROV and a UAV is positioning: an ROV must be tethered due to the inability to use Wi-Fi underwater, and GPS signals don't work underwater. Underwater positioning systems exist but are costly and complex, so they weren't used here. Instead, an ROV is calibrated before deployment, and its sensor provides vertical position and bearing on-screen, which is sufficient for tracking its position and movement. Before recording, all equipment must be checked, bolts and screws tightened, batteries charged, and the SD card erased and inserted (Figure 3).

After deploying the ROV, the first step was to dive to the sea bottom and locate the pipe's starting point. This was done by positioning the boat near the pipe's estimated location and using the bearing information on the monitor. Once found, the ROV was positioned about half a meter above the pipe to begin video recording. Although the ROV camera supports 4K, 1080HD footage was used to avoid glitches and excessive data.

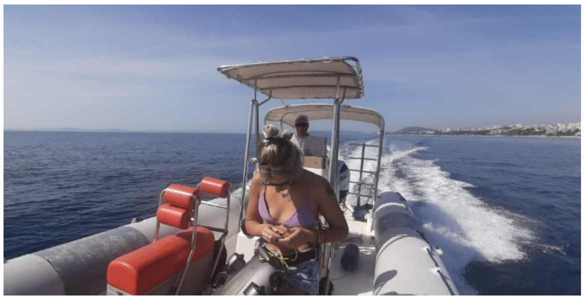

Figure 3. The Company's marine biologist making final preparations for an ROV before the deployment.

Initially, visibility was good because larger sediment particles were closer to shore, but after recording one-third of the pipes, the water became too turbid to see clearly (Figure 4). Recording had to be paused and resumed from more favorable points. In extreme conditions, the ROV had to be positioned very close to the pipe, which stirred up sediment and obscured the view. The main challenge was finding the optimal position to see the pipe without disturbing sediment with the ROV's propellers.

The main challenge was determining the exact position of the ROV, as they lacked a self-sustained positioning system like UAVs. The approach used involved estimating the ROV's position through available data: the pipe's direction, the ROV's depth, and the length of the marked tether. This forms a right-angle triangle, and using the Pythagorean

Theorem, the horizontal distance from the boat can be calculated. Although the tether is rarely fully stretched due to sea currents, this method provides a sufficiently accurate estimate of the ROV's position.

Figure 4. An illustration of ultimate turbidity in the footage of the Podstrana outfall - the pipe (right side of the photograph) is barely visible.

Although extreme conditions were found at most of the outfalls, there is an exception of the shortest outfall, yet with the deepest discharge point - the Nečujam outfall located on the northern part of the isle of Šolta. The sediment on this part of the seabed consists of gravel and rocks, which therefore resulted in a much lesser turbidity than at any other outfall. On such depths, daily light gradually fades, and therefore ROV's powerful LED lights had to be deployed, resulting in crystal clear, colorful images of the seabed at 60 meters depth (Figure 5).

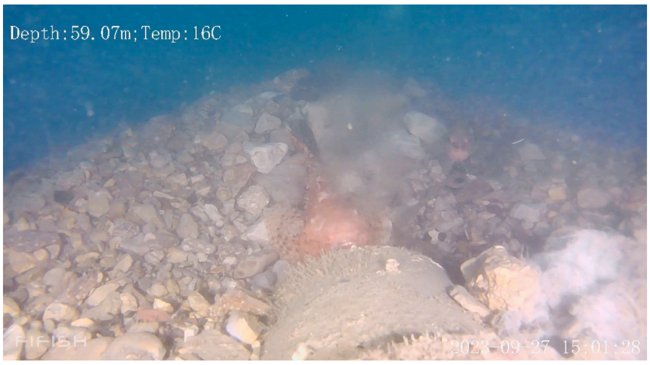

Figure 5. Discharge point of the Nečujam outfall at 60 meters depth, LED lights deployed.

3 Results

The purpose of this project was to record marine outfalls and discharge points to detect leaks, breaks, or other issues, and document their locations for future repairs by the utility. Despite several months of work in difficult conditions and some delays, the task was completed, and all necessary footage was finalized. Due to murky sea conditions caused by silty sediment and constant currents, recording had to be frequently paused and resumed from better positions. The footage was edited using Edius and compiled into unique videos for each outfall, accompanied by a written report and imagery mostly from video frames. The footage identified several pipe leaks and breaks, which were documented and included in the final report.

Split's aquatorium, with its silty seabed, posed significant challenges, contrasting with the clearer sea at the Nečujam outfall near Šolta island. The project took roughly three months, hampered by difficult conditions and unsuitable weather. The final footage of the Čiovo outfall was completed using a more stable flounder boat, which improved the ROV's course stability.

The results included separate 1080HD video footage for all eight outfalls, a written report, and detailed photos of pipe irregularities. Although the project took longer than expected, it was completed. Future similar tasks require better preparation, though experience and ROV pilot skills remain crucial.

4 Discussion

As this was the Company's first ROV task, difficulties arose due to inexperience. Despite these challenges, the mission was completed. Coastal utilities must regularly obtain video footage of marine outfalls, a task previously done by divers, which was time-consuming, costly, and dangerous, especially at depths over 50 meters in murky conditions. ROVs are likely the future of underwater outfall recording due to their efficiency, cost-effectiveness, quality footage, and the elimination of risky diver involvement. Other researchers in this field also stress the importance of divers' safety, but also the advantages of ROVs due to the elimination of human error, precision, and time efficiency (EyeRov 2024).

5 Conclusions

The utilization of widespread, cost-effective ROVs is a rising industry in the field of underwater exploration and monitoring of widely affordable ROVs whose prices vary from approximately two to thirty thousand euros. This engagement proved that highly dangerous, time-consuming, and costly operations which were previously conducted solely by divers and pertaining equipment can be performed with an ROV, achieving the same or even better results.

Some of the widely spread tasks that ROVs can perform are as follows:

- Exploration: ROVs can explore depths that are difficult or dangerous for humans to reach, such as deep ocean trenches or beneath ice shelves.
- Data Collection: Equipped with various sensors and cameras, ROVs can collect high-resolution images, videos, and other data about underwater environments.
- Sampling: Some ROVs are equipped with manipulator arms capable of collecting samples of sediment, water, marine life, or geological formations.
- Maintenance: ROVs are used for underwater infrastructure inspection, maintenance, and repair, such as pipelines, cables, and offshore platforms.
- Scientific Research: ROVs are essential tools for studying marine biology, geology, oceanography, and archaeology, enabling researchers to observe and document underwater ecosystems and phenomena.
- Search and Rescue: ROVs equipped with sonar and cameras can assist in search and rescue operations,

locating lost vessels or aircraft, and providing real-time information to rescue teams.

- Environmental Monitoring: ROVs can be deployed to monitor environmental parameters such as temperature, salinity, pH, and pollution levels in marine environments.

In conclusion, there are numerous ways of utilization of commercially available ROVs which will transfer a great load of highly demanding tasks from divers and the evermore robust and expensive equipment that has been used so far. Successful completion of this task adds to this statement, while numerous other tasks lay ahead, waiting for ROVs of increased features and capabilities which are being produced as we speak.

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