Chapter

# Underwater Technical Inspections Using ROV Applied to Maritime and Coastal Engineering: The Study Case of Canary Islands

*Sérgio António Neves Lousada, Rafael Freitas Camacho and Josué Suárez Palacios*

## Abstract

Underwater Technical Inspections using ROV have an important role in the design, construction, maintenance and repair of maritime and coastal infrastructures, trough video recording, digital photographs, collection of technical data and underwater topographic survey providing support for consultancy studies and projects and technical advice and appraisals. Routine inspections are the key to the maintenance of any submerged infrastructure. The importance of this type of inspection is increasing every day, but divers are also placed in increasingly dangerous scenarios to carry out this type of work. Inspections of underwater structures (as in dams, bridges, reservoirs, breakwaters, piers, oil rigs, etc.) have always been arduous and difficult, and often dangerous, but today underwater drones offer solutions that eliminate the risk faced by divers, and that also greatly reduce the high costs involved in such inspections.

**Keywords:** coastal engineering, construction, data, design, maintenance, maritime engineering, ROV, supervision, underwater inspections, video recording

## 1. Introduction

"ROV" (**Figure 1**) stands for remotely operated vehicle; ROVs are unoccupied, highly maneuverable underwater robots that can be used to explore ocean depths while being operated by someone at the water surface [1].

In a ROV, the connection between the vehicle and the surface is ensured by an umbilical cable that allows bi-directional communication, as well as energy supply to the vehicle. The use of this equipment in Underwater Technical Inspections, allows to reach greater depths and for a longer period than would be achieved using divers. In addition, it is possible to operate in contaminated waters that pose a risk to human life [2].

The vehicle is operated by the pilot from a command and control unit. This command includes two joysticks to control the depth and direction of the ROV, as well as commands to guide the video cameras (rotation and tilt), adjust the intensity of the lighting, control the articulated arm, and select the autopilot in direction or depth [2].

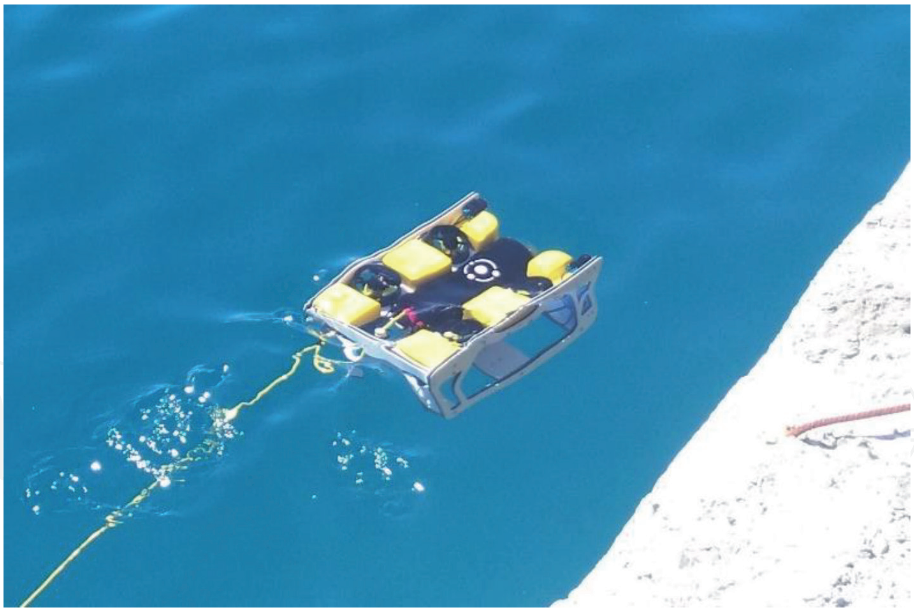

**Figure 1.**
*Equipment used SIBIU PRO (NIDO ROBOTICS): Maximum depth of 300 meters.*

The co-pilot assists in the navigation maneuver, as he is responsible for observing, analyzing and interpreting the sonar images and the acoustic positioning, giving indications to the pilot where to go [2].

The video signal is digitally recorded on magnetic tape, integrating information about the depth, the azimuth, the number of turns that the vehicle has accumulated on its own axis, as well as the date and time of the dive [2].

Most ROVs are equipped with at least a still camera, video camera, and lights, meaning that they can transmit images and video back to the ship. Additional equipment, such as a manipulator or cutting arm, water samplers, and instruments that measure parameters like water clarity and temperature, may also be added to vehicles to allow for sample collection [1].

First developed for industrial purposes, such as internal and external inspections of underwater pipelines and the structural testing of offshore platforms, ROVs are now used for many applications, many of them scientific. They have proven extremely valuable in ocean exploration and are also used for educational programs at aquaria and to link to scientific expeditions live via the Internet [1].

ROVs range in size from that of a small computer to as large as a small truck. Larger ROVs are very heavy and need other equipment such as a winch to put them over the side of a ship and into the water [1].

While using ROVs eliminates the "human presence" in the water, in most cases, ROV operations are simpler and safer to conduct than any type of occupied-submersible or diving operation because operators can stay safe (and dry!) on ship decks. ROVs allow us to investigate areas that are too deep for humans to safely dive themselves, and ROVs can stay underwater much longer than a human diver, expanding the time available for exploration [1].

## 2. Underwater technical inspections in Canary Islands

The underwater environment can be particularly harsh on structures, posing unique challenges to inspectors who must evaluate scour, material conditions or construction [3].

The technical inspection was carried out by Pharos Company using an underwater drone "ROV" (Remote Operated Vehicle), an unmanned underwater robot connected to a surface control unit by means of an umbilical cable.

The ROV used in this inspection is the "SIBIU PRO" developed by the company NIDO ROBOTICS, equipped with an HD camera, with 300 m of umbilical cable and four lights of 1,500 lumens. This ROV allows diving to a maximum depth of 300 m.

The following reports pretend to illustrate the reliability of Underwater Technical Inspections developed by similar companies around the world resorting to ROVs based on the study case of Canary Islands.

## 2.1 Canary Islands

The Canary Islands, also known informally as the Canaries, are a Spanish archipelago and the southernmost autonomous community of Spain located in the Atlantic Ocean, in a region known as Macaronesia, 100 km (62 miles) west of Morocco at the closest point (**Figure 2**). It is one of eight regions with special consideration of historical nationality as recognized by the Spanish government [4, 5].

The eight main islands are (from largest to smallest in area) Tenerife, Fuerteventura, Gran Canaria, Lanzarote, La Palma, La Gomera, El Hierro and La Graciosa (**Figure 3**). The archipelago includes many smaller islands and islets: Alegranza, Isla de Lobos, Montaña Clara, Roque del Oeste, and Roque del Este. It also includes a series of adjacent rocks (those of Salmor, Fasnia, Bonanza, Garachico and Anaga). In ancient times, the island chain was often referred to as "the Fortunate Isles" [6].


**Figure 2.**
*Spain (source: www.mapsofworld.com).*

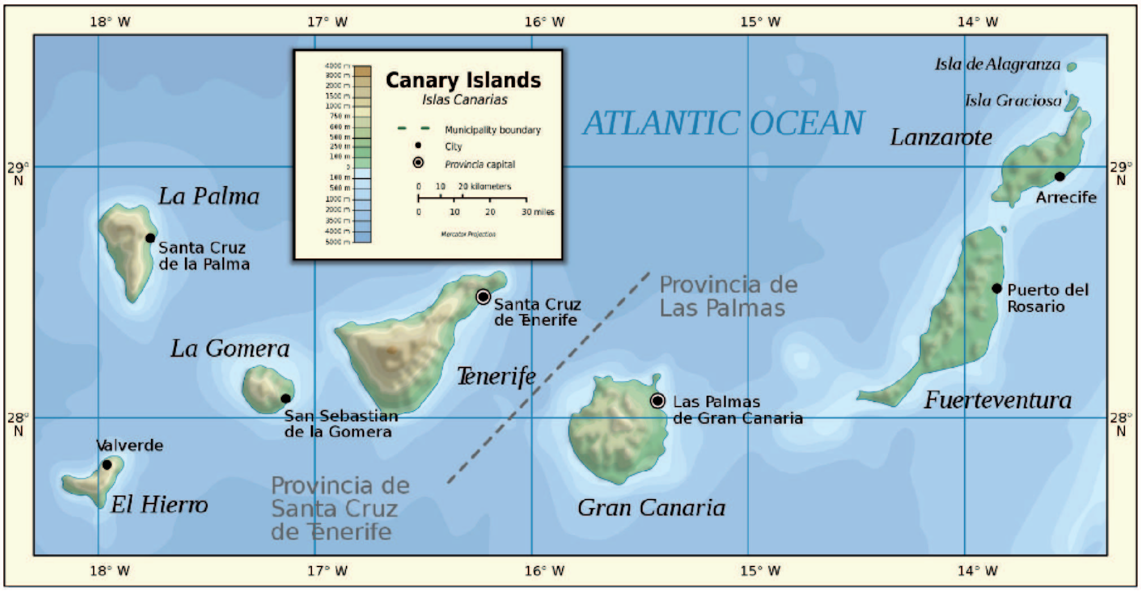


**Figure 3.**
*The Canary Islands (source: www.zonu.com).*

## 2.2 Inspection of interior docks (reinforced concrete quay blocks)

Two dives were carried out to control the execution of the interior docks expansion work (second phase), in the Las Palmas Port (**Figures 4–10**).

During the inspections, the following elements were visually controlled:

- Foundation of the quay blocks (bench, foundation and guard blocks);
- Condition of the concrete block wall as it closes to the RO-RO ramp;
- General condition of the vertical facing of the quay blocks;
- Completion of the lips of the docking superstructure;
- Location of wreck inside the Nelson Mandela dock.

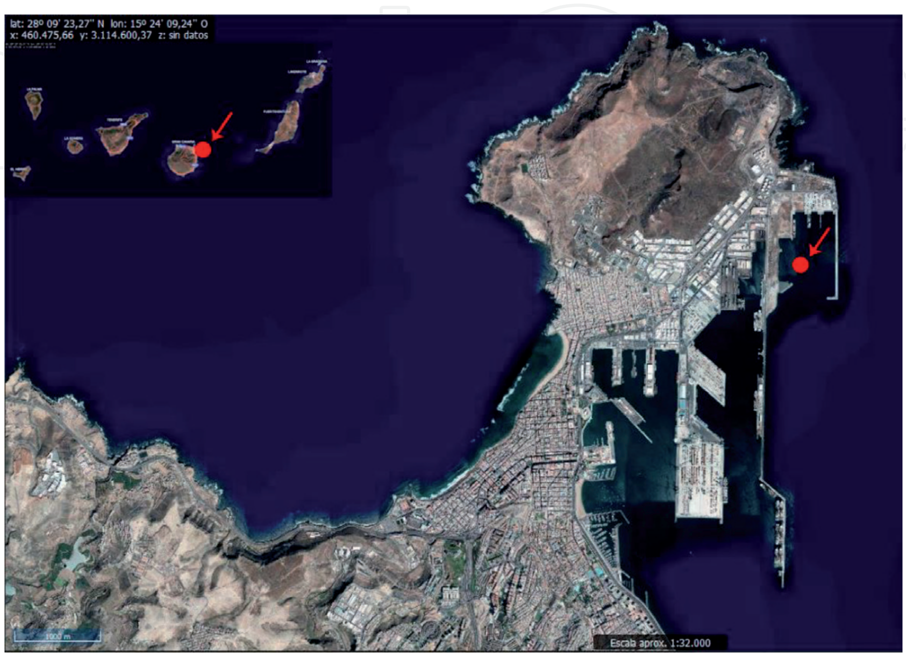


**Figure 4.**
*Interior docks, Port of Las Palmas.*

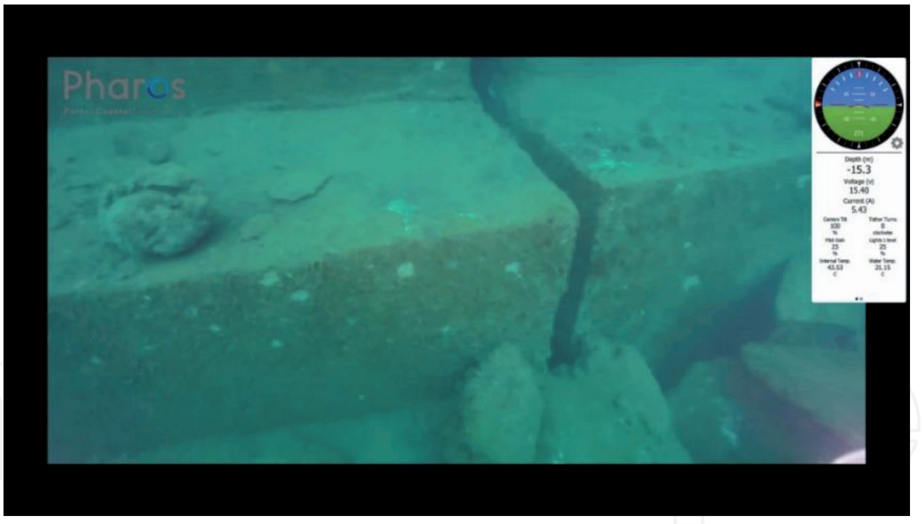


**Figure 5.**
*Quay blocks joint detail. Foundation footing.*

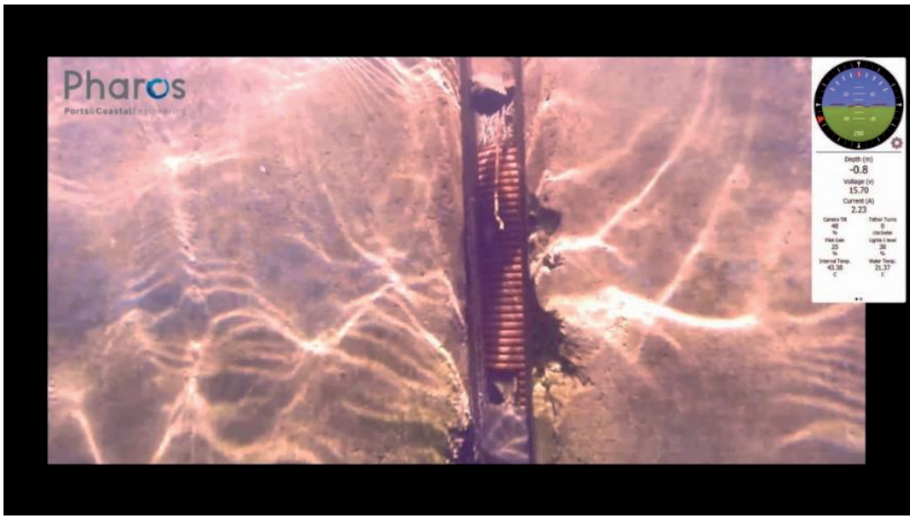


**Figure 6.**
*PVC pipe detail, quay blocks joint.*

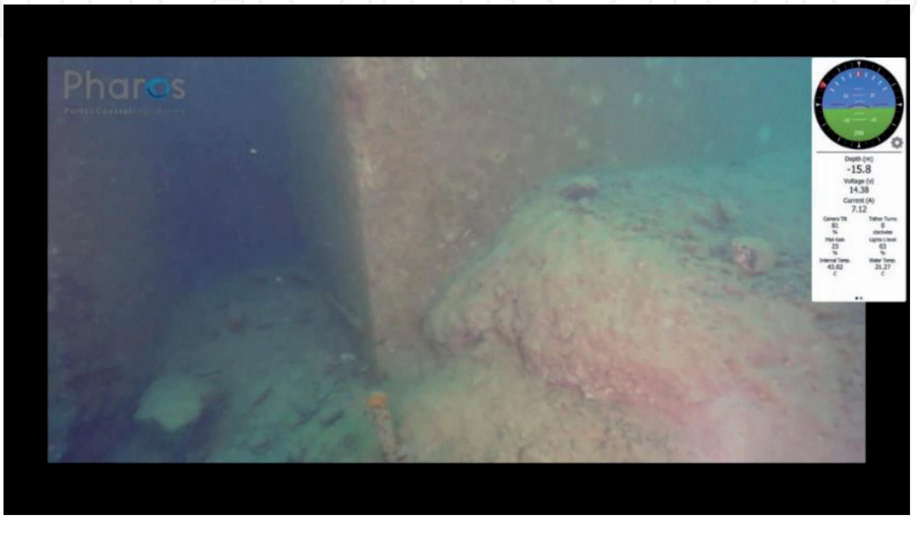


**Figure 7.**
*Detail of guard concrete executed in foundation.*

**Figure 8.**
*Lip finish of superstructure in submerged area.*

**Figure 9.**
*Defense detail and lip concreting joints executed with continuous trolley.*

**Figure 10.**
*Detail of the wreck found.*

### 2.3 Ro-Ro ramp inspection (bulk concrete blocks)

Two dives were carried out with the ROV to visually check the initial and final state of the repair of the berthing ramp of the passenger ships of the Shipping companies that operate in the Port of Las Palmas (**Figures 11–15**).

The elements to check were:

- Foundation of the bulk concrete blocks;
- General condition of the vertical wall, consisting of bulk concrete blocks;
- State of the finish of the ramp in its submerged part.


**Figure 11.**
*Ro-Ro ramp, Port of Las Palmas.*

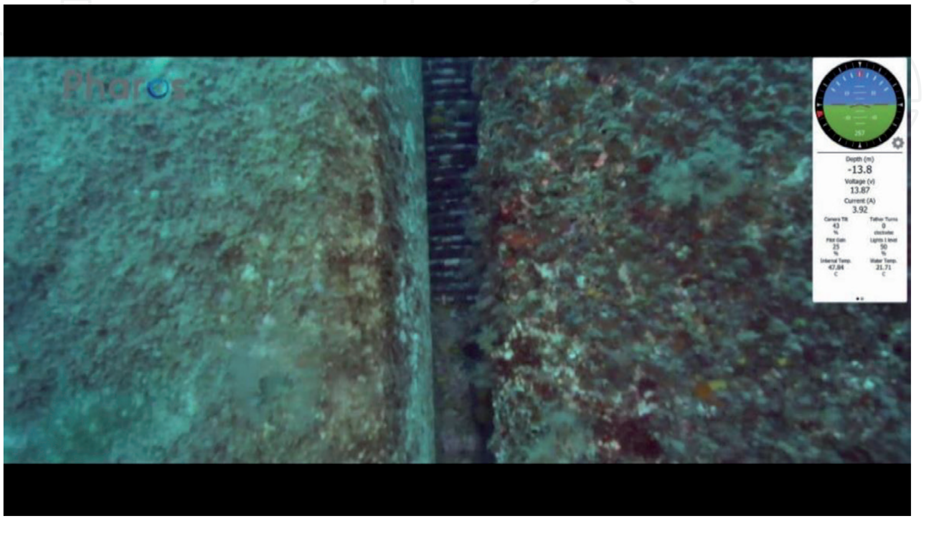


**Figure 12.**
*Detail of joint between concrete quay blocks in vertical face.*

**Figure 13.**
*Detail of the foundation of the ramp.*

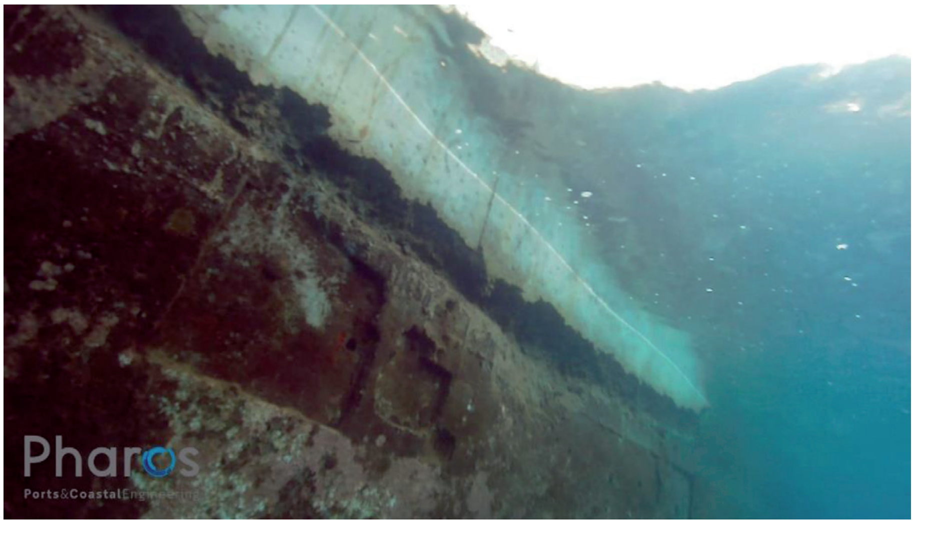

**Figure 14.**
*Ramp repair area.*

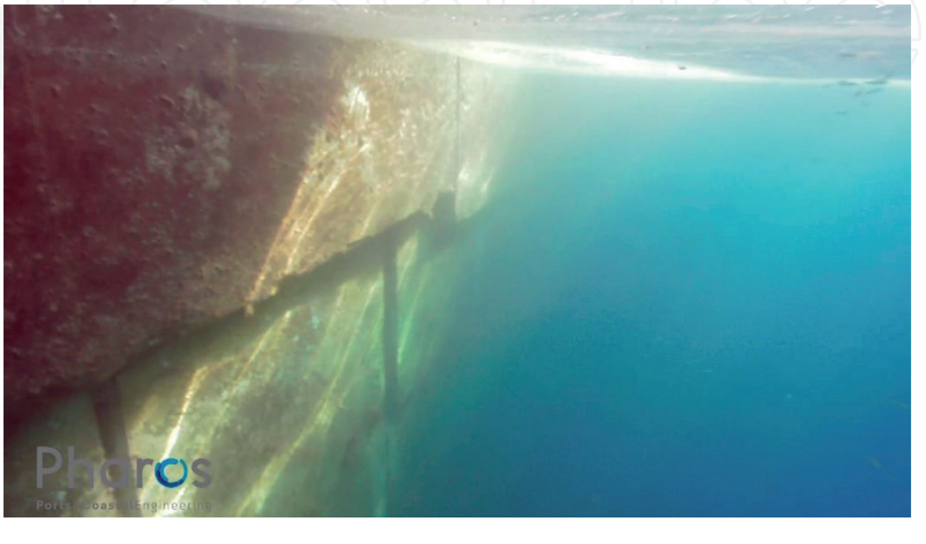

**Figure 15.**
*Vertical face of the ramp.*

### 2.4 Inspection of shelter dikes (reinforced concrete quay blocks)

#### *2.4.1 Port of Las Palmas, Gran Canaria*

An immersion was carried out with the ROV to visually check the state of the outer dock of the Port of Las Palmas, in the hammer area (**Figures 16**–**18**).

The items inspected were:

- Condition of the exterior and interior joints between quay blocks that make up the hammer;
- Condition of the foundation of the reinforced concrete quay blocks that make up the hammer;
- Condition of the concrete guard blocks in the exterior area.




**Figure 16.**
*Shelter dike, Port of Las Palmas.*

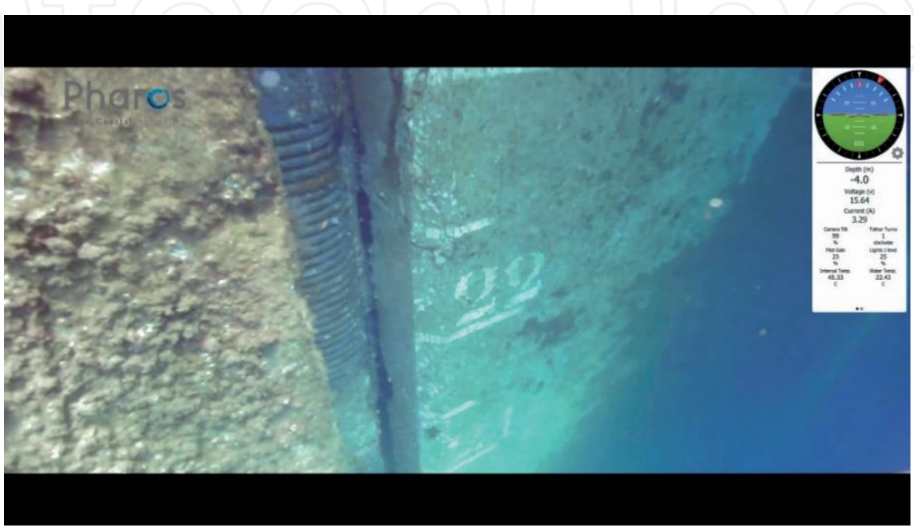


**Figure 17.**
*Detail of depth markers on the facing of concrete quay blocks and joint.*

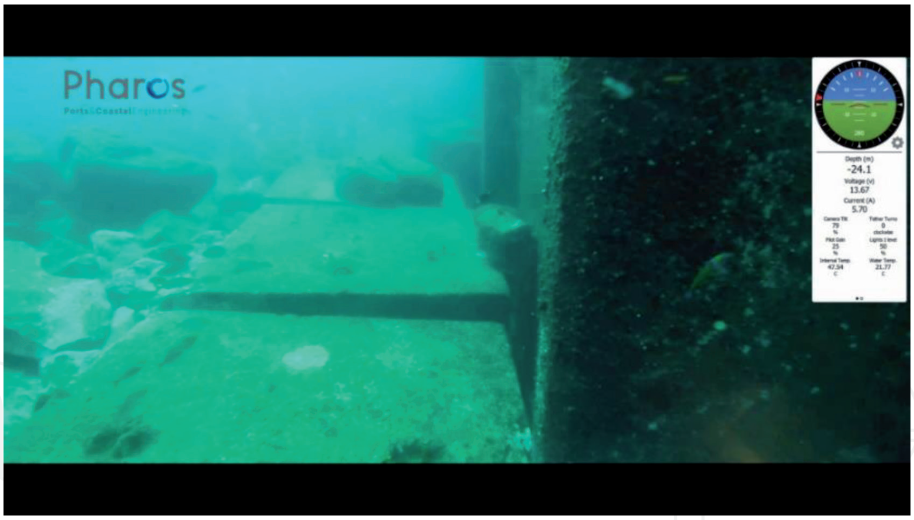


**Figure 18.**
*Guard concrete blocks on the foundation bank of the external dike.*

### *2.4.2 Port of Arrecife, Lanzarote*

A visual inspection of the submarine emissary of Arrecife was carried out by ROV (**Figures 19–22**).

The items inspected were:

- General inspection of the entire layout of the submarine emissary;
- Checking the state of the joints of the different sections of the pipe;
- Search for possible leaks in the pipe section;
- State of the concrete weights;
- Inspection of the state of the diffusers.


**Figure 19.**
*Shelter dike, Port of Arrecife.*


**Figure 20.**
*Detail of the diffuser system of the submarine emissary pipeline.*


**Figure 21.**
*Details of weights over the submarine emissary pipeline.*


**Figure 22.**
*Detail of the concrete weights in a pipeline section near the coast.*

## 2.5 Foundation slab inspection - Duke of Alba

Three visual inspections were carried out through ROVs during the construction and completion phases of the expansion work for the cruise berth in the Port of Naos (Arrecife) (**Figures 23–26**).

The Duke of Alba consists of a reinforced concrete slab and a superstructure on reinforced concrete piles with lost casing.

The elements to check were:

- Starting state of the piles on the foundation slab;
- Condition of the surface and perimeter foundation slab;
- Condition of the foundation bench;
- Estimation of the height of the executed foundation slab.


**Figure 23.**
*Foundation slab – Duke of Alba, Port of Arrecife.*

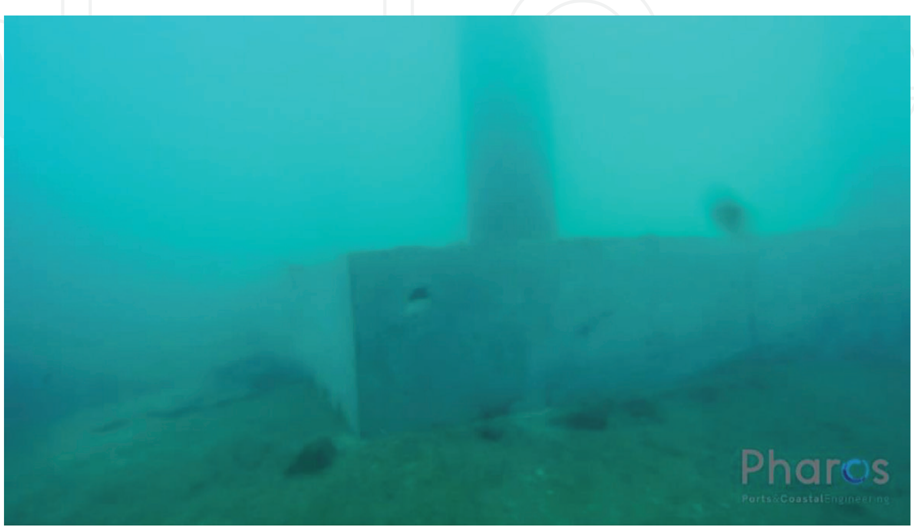


**Figure 24.**
*Duke of Alba's reinforced concrete foundation slab (Port of Naos).*

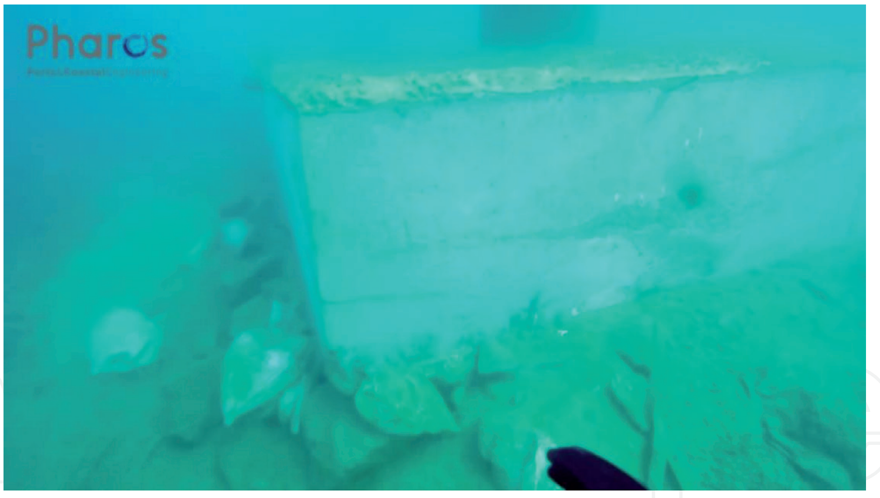


**Figure 25.**
*Corner detail of the Duke of Alba's foundation slab (Port of Naos).*

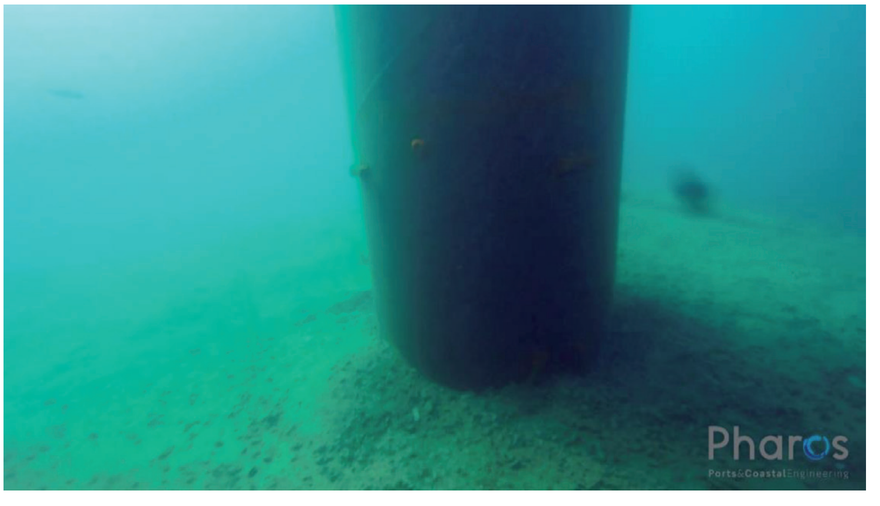


**Figure 26.**
*Detail of upper surface and pile in the foundation of the Duke of Alba (Port of Naos).*

## 3. Conclusions

In civil engineering, supervision, control, measurement and assessment of all phases of the work are essential: from project conception, planning, execution, including preservation and maintenance of infrastructures. This integral management model makes it possible to optimize resources and ensure that quality standards are achieved for works in progress and in service.

One of the handicaps that maritime work has had historically is the inherent difficulty of being partially or totally submerged in the aquatic environment. Underwater robotics and the reduction of the costs by using ROV equipment can constitute a turning point in the way of conceiving the management of works, quality and maintenance of the different coastal and port infrastructures.

The State Ports Administration - Spain (in Spanish: *Administración de Puertos del Estado*) and specifically the competent Port Authorities in the Canary Islands, have been promoting the use of the ROV as a new alternative for the management, supervision and maintenance of its infrastructures for a few years. The ROV is a highly reliable and safe, automatable and configurable technology that dramatically reduces costs and risks in underwater inspection operations.

The ROV is an equipment of the future and with a future, which is already an essential part in the present of maritime works and which, undoubtedly, is here to stay.



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## References

[1] NOAA, "What is an ROV?," NOAA, 2020. [Online]. Available: https://oceanexplorer.noaa.gov/facts/rov.html. [Acessed on 6 June 2020].

[2] Instituto Hidrografico, "ROV (Remotely Operated Vehicle)," Instituto Hidrografico, 2020. [Online]. Available: https://www.hidrografico.pt/info/19. [Acessed on June 2020].

[3] KCI, "Underwater Inspection and Commercial Diving," KCI, 2020. [Online]. Available: https://www.kci.com/services/transportation/structural-inspection/underwater-inspection-marine-engineering/. [Acessed on 6 June 2020].

[4] Gobierno de Canarias, "Reforma del Estatuto de Autonomía de Canarias," Gobierno de Canarias, 15 May 2006. [Online]. Available: https://web.archive.org/web/20060515081511/http://www.gobcan.es/reformaestatuto/index.aspx. [Acessed on 6 June 2020].

[5] Gobierno de Canarias, "Canarias en la España contemporánea: La formación de una nacionalidad histórica.," Gobierno de Canarias, 7 July 2016. [Online]. Available: http://coloquioscanariasamerica.casadecolon.com/index.php/CHCA/article/viewFile/7612/6583. [Acessed on 6 June 2020].

[6] T. Benjamin, The Atlantic World: Europeans, Africans, Indians and Their Shared HIstory, 1400-1900, Cambridge University Press., 2009, p. 107.