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Executive Summary

Ports and harbours depend on structures that spend their whole working life underwater. Piles, quay walls, docks, breakwaters and slope protection are attacked every day by seawater, tides, currents and waves, yet most of this damage happens out of sight below the waterline.

This paper explains how these structures deteriorate and why the damage is hard to track with occasional, manual inspection. It then sets out how remotely operated vehicles (ROVs) give port owners a practical, repeatable and well-documented way to see the true condition of their underwater assets, and describes step by step how an ROV-based pile and slope inspection is carried out and reported.

Deterioration Mechanisms and Inspection Limitations

Harbour walls, quays, docks, breakwaters and mooring piles are some of the main underwater structures in any port or harbour. These marine structures are exposed to seawater 24 hours a day, every day of their service life.

Seawater is a solution of dissolved salts, mostly sodium and chloride ions, along with dissolved oxygen. This makes it a good conductor of electricity, and that is what drives corrosion. Chloride ions break down the thin protective film that normally forms on steel, so steel piles, sheet piles and fittings begin to rust. In reinforced concrete, chlorides slowly travel through the concrete until they reach the steel bars inside. The rusting bars expand, which cracks the concrete from within and causes it to spall. Warm tropical water speeds up these reactions, and marine organisms that grow on the surface can create local pockets of even more aggressive attack.

The damage is not caused by salt alone. Tides raise and lower the water level twice a day, so the band of structure between high and low tide is wetted and dried again and again. Waves and splash keep the upper zone wet and rich in oxygen, which is where coatings often fail first. Currents and waves move sediment, washing it away from the toe of slopes in some places and piling it up in others. Propellers wash from large vessels and the force of berthing ships add to this, pulling at rock armour and the seabed beside the berth.

Over time, these forces lead to several types of damage:

- Corrosion and section loss of steel piles and fittings, which reduces their load-carrying strength.

- Cracking and spalling of concrete piles, deck beams and quay walls.
- Heavy marine growth, which adds weight and drag and hides the real condition of the surface.
- Armour displacement and exposed rockfill on breakwaters and slope protection.
- Scour at the base of structures, and siltation and sediment deposition in berth pockets and on slopes.

Together, these defects weaken the integrity and safety of the structure. If they are not found early, they can lead to load restrictions, berth closures and costly emergency repairs.

The challenge for port owners is that almost all of this happens below the waterline, in water that is often murky, tidal exposed and busy with vessel traffic. Conventional inspections tend to be occasional and depend heavily on written notes or short video clips. Without a fixed reference for each finding, it is hard to compare one survey with the next. Large areas such as rock slopes are difficult to cover evenly. As a result, many owners know how old their structures are but know far less about their present underwater condition.

An ROV-Based Approach to Underwater Inspection

Remotely operated vehicles (ROVs) bring underwater inspection under the control of the engineer on the surface. An inspection ROV is a compact underwater vehicle connected to a control station mostly by a tether. A trained pilot operates it from the jetty or a small boat, and the team watches live high definition video as the survey happens.

A compact ROV can move between closely spaced piles, work under jetty decks and follow the full length of a rock slope. Its thrusters hold it steady beside the structure, while protective guards and fenders prevent damage to both the vehicle and the asset. A neutrally buoyant tether cable carries power from the station and live data from the ROV without disturbing the inspections.

The vehicle carries an HD camera that tilts up and down the face of the structure, supported by a low-light camera and powerful LED lighting so the footage stays usable in dark, murky water. A laser scaler, carried as a payload, projects reference points onto the surface so that cracks, cavities and other defects can be measured. When the scope needs more, the same ROV can carry other payloads, such as an imaging sonar for very low visibility, an ultrasonic thickness (UT) gauge to measure remaining steel, or a cathodic protection (CP) probe to check whether corrosion protection is working.

ROV inspections follow the levels commonly used in underwater inspection practice. A Level I inspection is a general visual survey of the entire exterior of the structure, carried out without cleaning. It confirms that the structure matches its drawings and picks up obvious damage, heavy corrosion, marine growth and changes to the seabed. Because nothing is cleaned, it is quick, but it still covers the whole structure in enough detail to spot major problems. Its results then show where to focus a Level II inspection, in which selected areas are cleaned and examined closely, and a Level III inspection, in which measurements such as steel thickness are taken.

The value of the ROV approach lies in what it records. Every observation is tied to an exact location on the structure, all footage is kept, and the results can be compared directly with future surveys. This turns underwater inspection from an occasional check into a reliable record of how each asset is changing over time.

Conclusion

The underwater parts of a port face constant attack from seawater, tides, currents, waves and vessel activity. Corrosion, cracking, section loss, armour displacement and siltation build up slowly and out of sight, until they affect the safety and availability of the berth.

ROV-based inspection gives port owners a clear, documented view of this hidden zone. A Level I survey of piles and slopes shows where problems are forming, guides where closer inspection is needed, and creates a record that can be compared year after year. Used as part of a regular inspection programme, with surveys set by risk and repeated after events such as ship impacts or storms, it allows repairs to be planned and budgeted before they become urgent.

About EyeROV

EyeROV (IROV Technologies Private Limited) is a marine robotics company based in Kochi, India. It designs and builds underwater ROVs and unmanned surface vessels, and runs EVAP, a platform for post-processing and reporting underwater inspection data. EyeROV carries out ROV-based inspections of ports, jetties and other underwater infrastructure.

To discuss underwater inspection of your port or harbour structures, contact EyeROV at eyerov.com.