In-Situ Inc.

Innovations in Water Monitoring

White Paper

Antifouling System Reduces Algal and Biological Growth on the In-Situ TROLL® 9500 Water Quality Instrument

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Abstract

New regulations regarding clean water have increased the need for long-term environmental monitoring. As water quality sensor technology improves and becomes more stable, the limiting factor in these projects becomes biological and non-biological fouling of instrumentation. Biofouling of environmental equipment increases site visits and maintenance, which elevate monitoring costs. In addition, biofouling can affect data quality.

The In-Situ TROLL® Shield Guard is designed to extend typical deployments by inhibiting fouling on the surface of the TROLL® 9500 Water Quality Instrument. In-Situ Inc. has completed extensive testing of an antifouling solution to establish its effectiveness and usability. Prior to the experiments, a coiled copper guard was installed on a TROLL 9500 and deployed alongside a control TROLL 9500 to quantify performance of dissolved oxygen (DO), conductivity, ORP, pH, and turbidity sensors. Visual inspection and quantitative analysis determined the effectiveness of the antifouling solution. During a two-month deployment, the TROLL Shield Guard extended instrument deployment by up to six weeks longer than the control. See Figure 1.

Introduction

With the ever increasing need to monitor diminishing water supplies has come the need to understand environmental changes and factors contributing to those changes. By routinely monitoring water quality parameters, possible contamination and changes in

Figure 1. TROLL 9500 Water Quality Instrument with TROLL Shield Guard

water consistency can be detected. During the last two decades, clean water regulations have increased, and regulators, legislators, and citizens want to understand what is discharged into water and by whom. As these requirements increase, it has become important to develop methods for monitoring environmental conditions and for improving existing techniques.

Traditional methods for environmental monitoring include sample collection followed by analysis at a state-regulated laboratory. Although this is an accurate technique, it has some limitations. For example, samples can degrade, which affects analytical accuracy; and spot checking limits understanding of daily changes. These limitations have inspired technological advancements that allow the user to characterize a site continuously rather than by spot sample analysis.

Long-term monitoring provides a daily representation of a site and can immediately indicate a disturbance in the homeostasis of the environment. In addition, the site controller can act quickly if an issue arises. Water quality instruments can measure conductivity, DO, ORP, pH, turbidity, water depth, and nutrient levels of various environments. Each of these parameters can act as an indicator of change in water composition and can trigger further investigation into possible contamination.

Long-term environmental monitoring also has limitations. The leading source of error during long-term deployments is biofouling and its affect on sensor accuracy and performance. Biofouling is the accumulation of waterborne biological organisms on a submerged surface. Biofouling can be microscopic, organic, inorganic, bacterial, algal, plant, or invertebrate. The extent of biofouling varies from site to site with greater impediment in warm areas with saline water such as coastal and equatorial regions.

The degree of biofouling on an instrument is directly proportional to the impact on the performance of the sensors on the water quality instrument. The more biofouling present the greater the impact on sensor performance. Most water quality sensors rely on open exposure to the media in order to produce accurate results. As sensors become covered with biological organisms and debris, exposure to the media decreases, which leads to decreased sensitivity and accuracy. Some of the problems associated with biofouling include:

- Increased site visits to clean and service the equipment
- Inaccurate data due to sensor drift
- Increased time spent post correcting data to compensate for fouling
- Data loss due to extensive off-site cleanings
- Permanent damage to the sensors

All of these factors add expense in the form of site visits, downtime, and sensor replacement. Short-term, fouling that covers the sensing material results in slow response and reduced accuracy. Fouled sensors can require full cleaning, service, and user calibration in order to bring performance back within manufacturer specifications. Permanent sensor damage, a long-term implication of fouling, leads to replacement of the sensors or the entire instrument. In either case, biofouling is expensive due to material costs, data loss, and increased staff-hours.

Many manufacturers have tested and implemented a variety of antifouling strategies. Each was designed for a specific budget and application. Methods to address biofouling include the use of mechanical devices, antifouling coatings, biocide-infused coatings or paints, irradiation, and electrochemical devices. Mechanical devices typically consist of a wiper, air, or water blast system, or include a vibration or a shutter mechanism. Mechanical devices are fairly effective but have drawbacks. Most require a power supply in order to function properly, yet most sites do have power readily available. In addition, a wiper can itself become fouled. This can cause additional abrasion of the sensing materials and lead to untimely degradation of the sensor. Mechanical devices can fail, thereby flooding instruments, causing the need for additional maintenance.

Antifouling coatings and paints have proven most effective for marine environments. These coatings do not, however, adhere to all materials and can be ineffective for certain sensors and instruments. In addition, antifouling coatings can be expensive or release hazardous chemicals into the environment. Coatings with infused biocides work well, but are typically too expensive for most manufacturers to use on their equipment or for environmental agencies to purchase.

Irradiation uses ultraviolet light to mitigate biofouling, but is not a viable option due to power constraints and deployment regulations. Lastly, electrochemical antifouling devices use metal oxides, or other chemicals, to deter or neutralize organismal growth. As a relatively inexpensive method, this has become the primary solution for most deployment extensions.

Multiple criteria must be considered when selecting an antifouling system. A thorough site evaluation will determine the types of fouling and environmental sensitivity that may exist. For example, using a copper-based antifouling device is not effective in a wastewater application due to the fact that the limiting factor is sedimentation rather than organismal growth. In addition, choosing an option that requires power at a site with no power may require the purchase of additional equipment, such as solar systems or long-lasting battery packs. Another item for consideration is the material of the instrument and sensors. Under certain conditions, some antifouling strategies can

Figure 2. Site #1 in South Charleston, West Virginia

interfere with sensor performance or attack the material of the instrument. Defining the length of deployment and site-specific limiting factors can help determine if the site requires a solution for weeks, months, or years. For most long-term deployments, the limiting factor is battery life. Most batteries last only one to two months depending on sampling interval. For this type of deployment, it is unnecessary to purchase an antifouling solution designed to extend deployment for a year. Finally, cost limits the options available to most sites. Deployment strategies that extend an operation for more than a couple of months are often outside of the yearly budget.

Choosing the right antifouling deployment strategy can lower the number of site visits, decrease the maintenance requirements per site, reduce the required staff-hours, increase data quality, and decrease the cost-per-data point. Overall, the majority of antifouling strategies can lower project costs by allowing for extended deployments.

Method

This test was designed to verify the viability of an antifouling solution for the In-Situ® TROLL® 9500 Water Quality Instrument. Of primary importance was the ability to extend deployments on conductivity, DO, ORP, pH, and turbidity sensors. The TROLL® Shield Guard, which includes a high-purity copper alloy, is attached to the TROLL 9500 Instrument (see Figure 1).

During the study, four sites were monitored. Site conditions ranged from freshwater to saltwater in high- and low-flow applications. Sites included:

- South Charleston, West Virginia
- Arnaudville, Louisiana
- Pass Christian, Mississippi
- Isaac Creek, North Carolina

Prior to deployment, all sensors were calibrated according to manufacturer recommendations and checked for accuracy. Each site included a control unit, a TROLL 9500 without a guard, and an experimental unit, a TROLL 9500 with a guard. This experimental design was intended to quantitatively and qualitatively determine the effectiveness of the guard.

Deployments were left for two to three months, and instruments were set to collect data at 15-minute intervals. Initial data from each location was recorded and used to evaluate sensor drift after deployment. During deployment, the site was photographed and any anomalies were noted. Data was downloaded every two to three weeks. No instruments were cleaned during deployment. At the end of deployment, instruments were removed and photographed to visually document fouling. Readings were taken in standard solutions to determine drift due to fouling. Instruments were cleaned and readings were taken in standard solutions to determine sensor drift independent of fouling. Data was analyzed to determine the effectiveness of the TROLL Shield Guard for the TROLL 9500 Instrument in a variety of environmental conditions.

Results

The following data show the results of the deployments. The TROLL Shield Guard extended instrument effectiveness during deployment for up to six weeks longer than the control. All instruments that were fitted with the guard showed improved sensor readings for longer periods of time as compared to control instruments.

Site #1: South Charleston, West Virginia, Department of Natural Resources

This West Virginia site (see Figure 2) is a high-temperature freshwater site with fouling primarily in the form of algae and plant growth. The TROLL 9500 installed with the guard extended the deployment by approximately six weeks more than the control (see Figure 3).

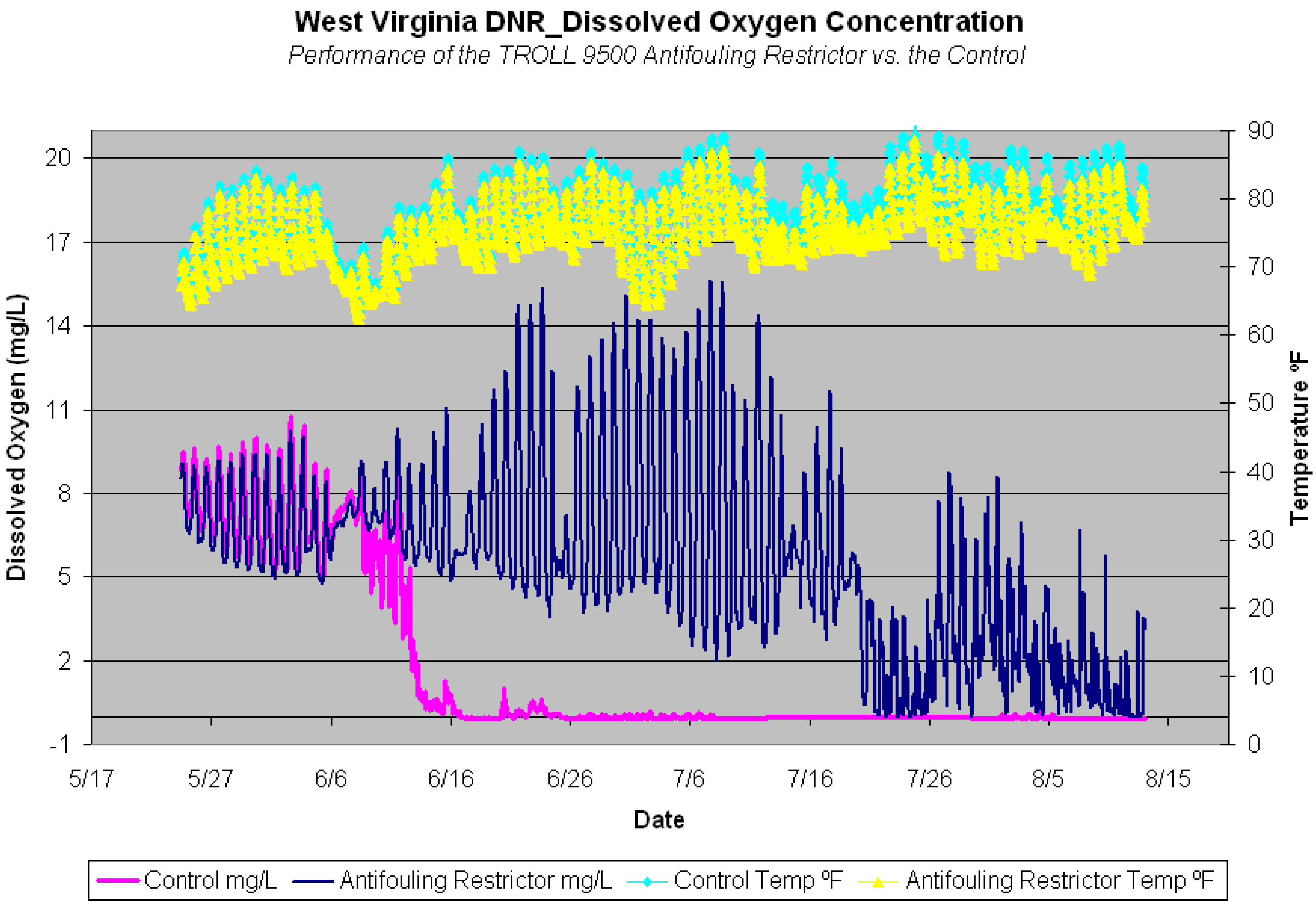


Figure 3: This graph compares DO readings for both control and experimental instruments deployed at Site #1. The experimental instrument with the TROLL® Shield Guard collected data for six weeks longer than the control unit.

Site #2: Arnaudville, Louisiana

This site is a saltwater site that presents fouling in the form of algal growth (see Figures 4 and 5). The TROLL® 9500 deployed with the guard resulted in a one-week deployment extension over the control (see Figure 6). In addition, the guard greatly reduced the amount of growth on the sensors (see Figures 7 and 8).

Figure 4: Site #2 in Arnaudville, Louisiana

Figure 5: Control instrument (right) and experimental instrument with TROLL Shield Guard (left) being deployed at Site #2.

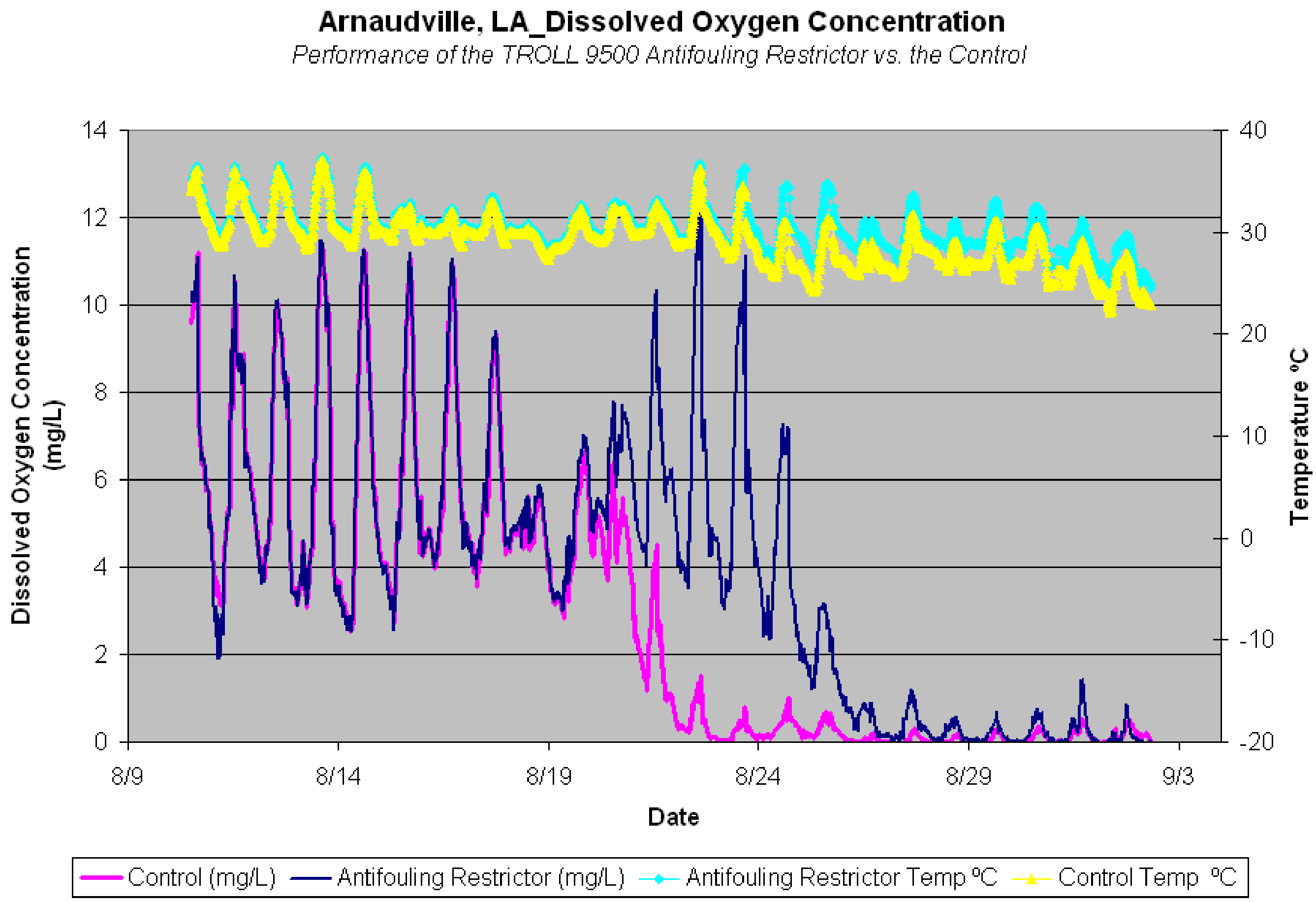


Figure 6: This graph compares DO readings for both control and experimental instruments deployed at Site #2. The experimental instrument with the TROLL Shield Guard increased deployment time by one week over the control unit.

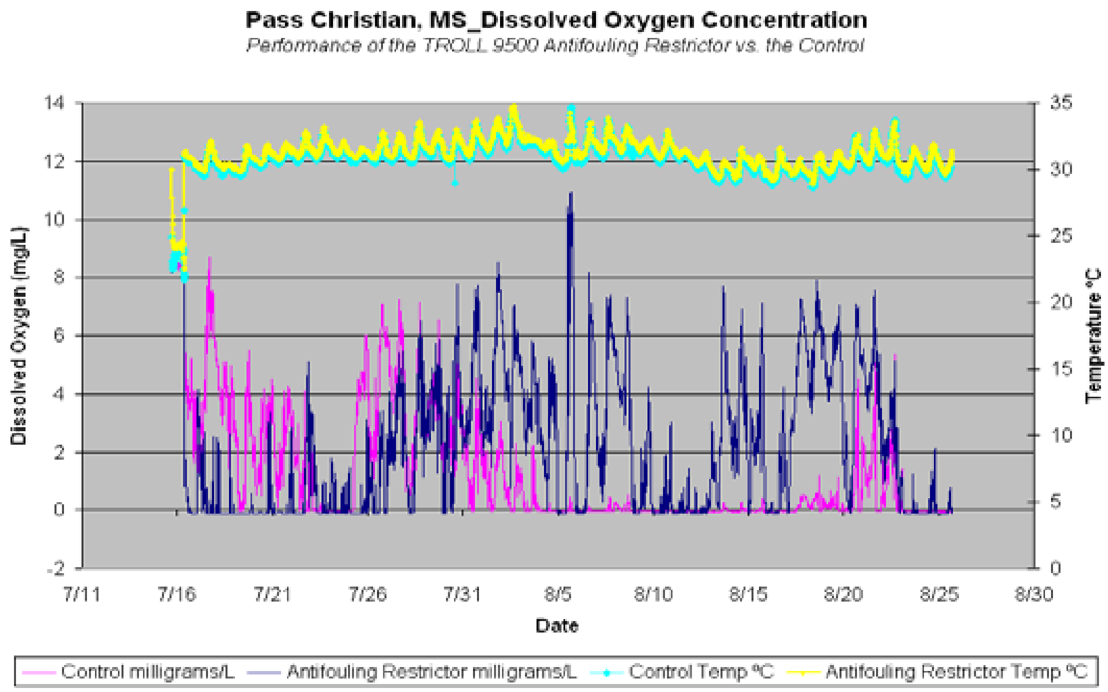
Figure 7: Sensor fouling on the control instrument after 25 days at Site #2

Figure 8: Sensor fouling on the experimental instrument after 25 days at Site #2

Site #3: Pass Christian, Mississippi

This site is a high-fouling saltwater site that exhibits algal and organismal fouling. The guard had a positive impact on DO and ORP readings (see Figures 9 and 10). The guard decreased fouling on the sensors (see Figure 11).

Figure 9: The graph compares DO readings collected by both control and experimental instruments at Site #3.



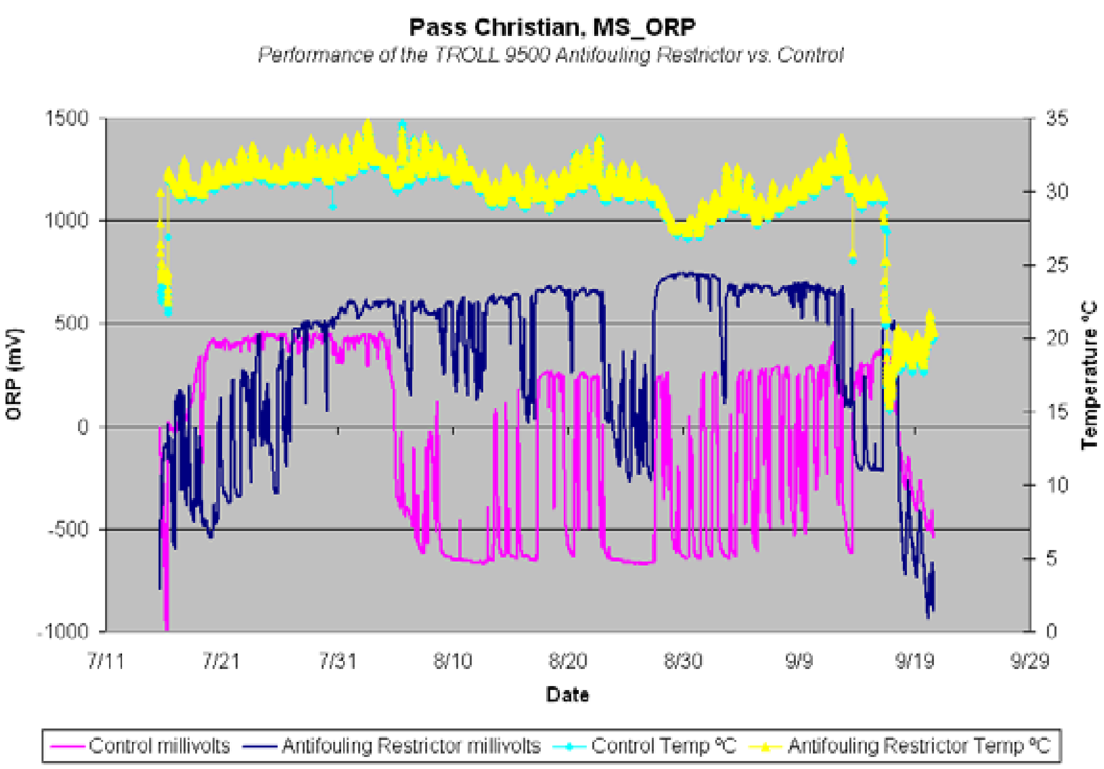


Figure 10: The graph compares ORP readings collected by both control and experimental instruments at Site #3. Fouling on control sensors resulted in an offset for the duration of deployment.

Figure 11: Control instrument (left) and experimental instrument (right) deployed at Site #3

Site #4: Isaac Creek, North Carolina

Isaac Creek is a saltwater site (see Figure 12) relatively high temperatures. The majority of fouling is algal growth. The TROLL 9500 with guard showed reduced fouling (see Figures 13, 14, 15).

Figure 12: Site #4 at Isaac Creek, North Carolina

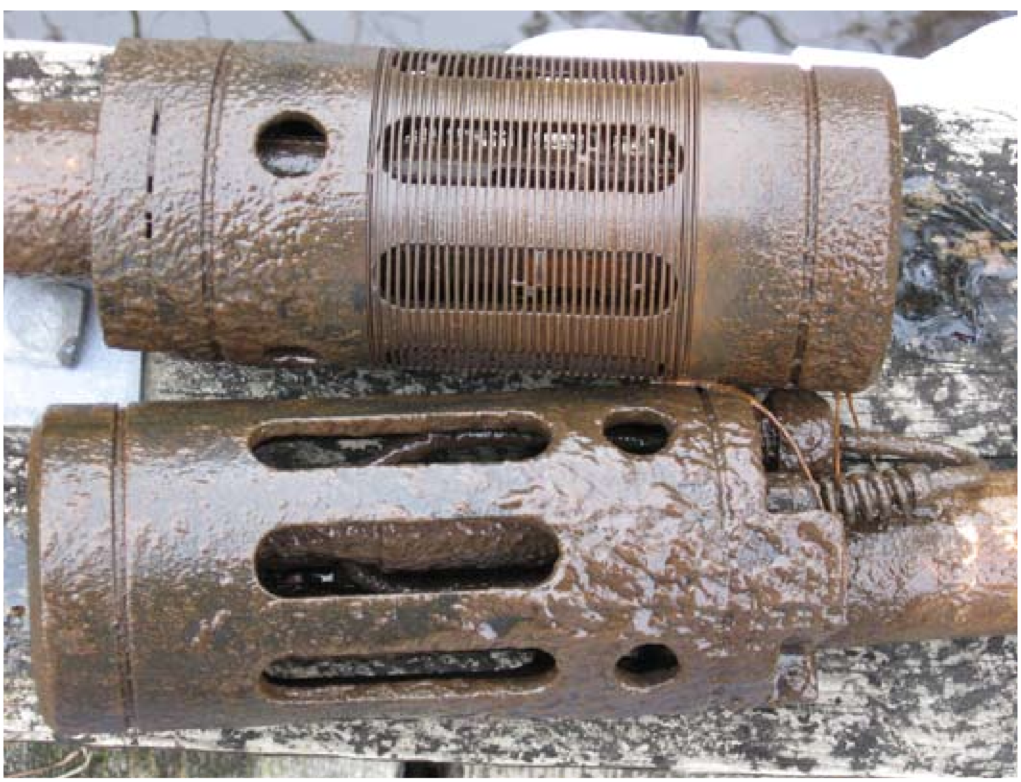


Figure 13: Control instrument (bottom) and experimental instrument with TROLL Shield Guard (top) deployed at Site #4

Figure 14: Control instrument after two-month deployment at Site #4

Figure 15: Experimental instrument after two-month deployment at Site #4

Conclusions

With increased interest in low-cost, long-term environmental monitoring, products that reduce biological fouling on water quality instruments are required. New antifouling strategies have lengthened instrument deployment, which results in fewer site visits, decreased maintenance, lower cost-per-data point, and better quality data.

The In-Situ TROLL® Shield Guard extended instrument effectiveness for up to six weeks in high-fouling environments. The guard can reduce the cost of data collection and improve confidence when analyzing long-term environmental data.

References

Alliance for Coastal Technologies. November 2003. Biofouling Prevention Technologies for Coastal Sensors/Sensor Platforms. UMCES Technical Report Series: TS-426-04-CBL/ Ref. No. [UMCES] CBL 04-016.

Delauney, L., Compère, C., Lehaitre, M. May 2010. Biofouling Protection for Marine and Environmental Sensors. Ocean Science. 6:503-511.

Whelen, A., Regan, F. June 2006. Antifouling Strategies for Marine and Riverine Sensors. J. of Environmental Monitoring. 8:800-886.

U.S. Environmental Protection Agency
http://www.epa.gov/epahome/learn.htm
http://www.epa.gov/research/sciencematters/august2010/oil-spill.htm
http://www.epa.gov/research/sciencematters/october2010/ailing-stream.htm

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