Recent Advances in Biofouling Protection for Oceanographic Instrumentation

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Abstract

Although biofouling continues to be one of the most significant factors limiting the long-term deployment of oceanographic instrumentation, recent advances in technology advances are providing highly effective mitigation of this problem. The use of foul release coatings in conjunction with other biofouling control methods and best practices provide significant improvements in instrument deployment times and reductions in maintenance schedules. This paper examines the combinations of technologies and best practices for the biofouling control of oceanographic instruments and their associated platforms.

Introduction

Biofouling is one of the single biggest factors affecting the cost, operation, maintenance and data quality of undersea sensors. This is especially true for instrumentation deployments in the photic and coastal zones.

The major impediments to long-term instrumentation deployments used to be data storage and battery life. Over the last decade, oceanographic instrumentation has become more power efficient, better battery systems have evolved and data capacities greatly increased. Now as a result of these overall instrument improvements, the major impediment to longer instrument deployments for many operational scenarios is biofouling accumulation.

Historic Practices

Historically, bio-fouling control has been achieved by exploiting the toxicity of metals, organometals and other similar biocides to marine invertebrates and incorporating them in paint matrixes to form antifouling coatings. This traditional approach to biofouling protection using paints is in most cases inadequate for oceanographic instruments for a number of reasons. Such traditional approaches have a number of deficiencies: a lack of clarity for optical instruments, occupational hazards associated with instrument handling, limited life of antifouling paints, occupational hazards of removing antifouling paints when re-coating, weight changes occurring from paint and biocide release for bouncy sensitive instruments and the inability to use on flexible substrates when required.

Other antifouling techniques that are sometimes used on oceanographic instrumentation such as ablative greases or greases contain various pepper extracts were are also historically used but judged to be unacceptable when evaluated against more refined approaches for the biofouling control.

Integrated Systems for Biofouling Control

One of the incorrect approaches for biofouling control for oceanographic instruments to date is the notion that there is a one size fits all biofouling control method. The more refined strategy is the use of specific biofouling control methods for specific instruments, mission types and sensor types.

Biofouling control for oceanographic instruments is best achieved through a multi-tiered integrated approach. Specifically, the selected use of foul release coatings, ultraviolet (UV) sterilization, mechanical cleaning, and chemical immersion offer greater effectiveness for controlling biofouling on many instruments. Another paramount consideration is the hydrodynamic streamlining of instruments and their associated platforms.

Effective Systems for Biofouling Control on Oceanographic Instruments

Specialized Biofouling Control Systems

The recent advances in biofouling control methods for oceanographic instruments and related platforms represent a significant improvement over the historic practices noted.

One of the most effective biofouling solutions over the last 10 years is the use of non-stick or "foul release" coatings that have been formulated specifically for use on oceanographic instruments.

Foul release coatings rely on the surface properties of the material itself to significantly reduce biofouling settlement. They also greatly reduce the work required to clean an instrument or platform. These coatings are particularly effective on instrument housings, acoustic transducers and host platforms such as surface and subsurface gliders. Foul release coatings can be self-cleaning in high-energy environments such as moving platforms or wave environments. These coatings are designed to last the lifetime of the instrument, thereby making them cost effective solutions for many applications. While the foul release coating system is effective on instrument housings and acoustic transducers it is in many cases not a suitable biofouling control system for non-acoustic sensor elements.

There are many cases where the sensor elements are not compatible with coatings or must maintain a more pristine surface than can be achieved with foul release coatings.

UV treatment/sterilization systems have been refined over the last several years and are now commercially available for instrument users. The systems operate by using a UV light source that is focused on the sensor area to be protected. This is a non-contact solution that has proven to maintain a pristine surface on many non acoustic sensors. The power required for the UV systems is 20 MA to 40 MA with present duty cycles of 50% being commonly used. For multiple sensors the power consumption of UV systems has to be taken into account where a finite power source such as batteries are used.

Liquid sterilization systems are also a fairly new addition to the suite of biofouling control solutions available to the oceanographic instrumentation user community. The newer liquid sterilization systems use a chlorine solution that is injected into the sensor area. A typical configuration of this type of device is the use of a housing or enclosure that encapsulates the sensors to be protected. The liquid chlorine solution is then injected into the enclosure area where it is held for an adequate residency time. Liquid sterilization systems of this type have been proven to have an effective duration for up to three months. It is believed that longer durations can be achieved with refinements to this technical approach.

A variety of wiper systems are available from many of the manufactures of non-acoustic oceanographic instruments. These systems perform with varying degrees of effectiveness depending on the wiper material type, overall design and operational environment. Wipers do require battery power and in high biofouling environments are eventually overwhelmed by the biofouling.

Table 1 describes the recommended biofouling control methods described and providers of commercially available systems.

Table 1

Control Method	Application	Commercial Manufacturers
Foul Release Coatings	Instrument Housings, Acoustic Transducers, Undersea and Surface Platforms	Severn Marine Technologies, LLC, ClearSignal®
Liquid Sterilization	Optical Sensors, Membrane Sensors	Green Eyes, LLC- Probe Guard™, Wetlabs/Sea-Bird Scientific
Wiper Systems	Optical Sensors	YSI/Xylem, Turner Design, Wetlabs/Sea-Bird Scientific
UV Sterilization	Optical Sensors, Membrane Sensors	AML Oceanographic- UV•Xchange™ Wetlabs/Sea-Bird Scientific

Turbulence and Streamlining

The most overlooked contributor to the onset and propagation of biofouling is the presence of flow separation around the bodies and protruding appendages of oceanographic instruments and platforms. The resulting flow separation on the submerged instrument or platform results in low pressure, low fluid flow areas that are highly favorable for the settlement and growth of biofouling organisms.

The simplified explanation of flow separation is that it occurs around any non-streamlined body in a moving fluid due to the viscous forces on the submerged bodies surface. While flow separation can occur as a laminar flow condition, it is almost always associated with turbulent flow in water and especially in the typical environments associated with oceanographic instrument deployment. The sources of the water movement around the submerged instruments or platforms (bodies) are waves, currents, and platform movement.

It is interesting to note that undersea vessels, surface vessels and towed bodies are often designed to be streamlined for hydrodynamic efficiency, as one of their primary functions is to be low drag bodies. Oceanographic instruments, on the other hand, are rarely designed with hydrodynamics in mind, as their primary function is the sensing and acquisition of a particular data type.

Several examples of biofouling settlement due to turbulent induced flow separation are shown in photos 1 and 2.

Photo 1: The Scarlett Night Glider on its historic Atlantic crossing. The biofouling occurs as a result of turbulence/flow separation at seams of the O-ring sections.

Photo 2 shows a typical multi-sensor configuration. The biofouling occurs at sensor faces where turbulence/flow separation occurs at the interface of the wiper system and sensor areas.

Conclusions

The adoption of the best practices and integrated solutions for biofouling control described will extend the deployment times of these instruments by a significant amount. The most overlooked and underutilized area of improvement is the adoption of streamlining for oceanographic instruments. For the majority of oceanographic instrument deployments the best practices include:

- The use of a foul release coating on instrument housing and acoustic elements,
- The use of specialized sensor biofouling control; methods such as UV Sterilization and chemical immersion
- The implementation of streamlining techniques to reduce turbulence and flow separation

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