ClearSignal Coating Controls Biofouling On the Rutgers Glider Crossing

A Nonstick Coating Gives the Scarlet Knight Glider Permanent Biofouling Control on Trans-Atlantic Mission

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One of the most exciting new tools in present day oceanography is the glider, which can perform sustained collection of oceanographic data. Gliders are unique in that they provide the ability to conduct long-term oceanographic data collection missions on a mobile and directionally controllable platform.

The glider's performance is derived from its highly efficient buoyancy-derived propulsion system, enabling the platform and associated sensors to be deployed for many days or even months of sustained oceanographic sensing over navigationally controlled long distances.

The attributes of the glider—extended mission deployments and high-efficiency, low-power propulsion—are not without operational vulnerabilities. By virtue of their extended immersion times, long-deployment glider missions have an increased susceptibility to the settlement of biofouling organisms on all of the glider's exposed surfaces. Even a low to moderate degree of biofouling can impart enough hydrodynamic drag to significantly inhibit or prevent both forward movement and directional control of the glider.

Biofouling on Gliders

A glider's susceptibility to biofouling attachment depends on a number of environmental and operational factors. The most important of these are geographic location, water temperature, mission duration, operational depths and the seasonal variabilities of biofouling organisms. In general, seasonally warmer waters and shallower depths are more conducive to biofouling settlement. The gooseneck barnacle is the most common biofouling organism that gliders and other open-water platforms encounter.

View of barnacle-free areas coated with ClearSignal and barnacle attachment on areas with high turbulence not coated with ClearSignal.

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Glider prior to biofouling.

(Below) Recovery of the Scarlet Knight.

Scarlet Knight Atlantic Crossing

Rutgers hosts a glider team consisting of several professors/principle investigator scientists, an equal number of glider-dedicated engineers and technicians and a significant contribution from both undergraduate and graduate students. The overall goals of the team are to use and advance the capabilities of gliders for oceanographic data acquisition in support of advanced climate studies.

The team configures and operates several gliders manufactured by Teledyne Webb Research Corp. (East Falmouth, Massachusetts). The scientific data collected from glider missions is used to further develop and refine oceanographic prediction models that are a major component of climate and climate change studies.

One of these gliders, the Scarlet Knight, recently completed a trans-Atlantic crossing conceived so as to fulfill the following mission requirements: proving the ability of gliders to perform long-duration missions, collecting critical physical oceanographic data during the transit and providing a complex and science-based mission that could in large part be run by students.

The Scarlet Knight was launched on April 27, 2009, off the coast of New Jersey and recovered on December 4 off the coast of Northern Spain, having traveled a distance of just more than 4,600 miles.

Controlling Biofouling on Gliders

In the years leading up to the Scarlet Knight mission, as the Rutgers team worked on extending the mission durations of their glider fleet, it became increasingly evident that biofouling was becoming a major factor limiting shallow (less than 200 meters) glider mission durations and transit distances achieved.

In response to this concern, the Rutgers team initiated an investigation to determine if a suitable biofouling control technology existed for use on their Scarlet Knight glider. The first steps in the investigation were the development of a glider biofouling coating performance criteria and an analysis of available biofouling control solutions.

A somewhat unique requirement for gliders is that of a constant density anti-fouling coating. Gliders are ballasted and trimmed to within several grams of weight and must remain at this set condition for the entire mission. Durability, long-term effectiveness and safety in handling are obvious attributes that must be achieved by a biofouling control system. A final desired attribute is for the coating to be optically clear. This enables the glider as configured to retain its identity of color, logos and other identifying markings, including contact numbers and handling instructions for vessels it may encounter on its mission.

Traditional Biofouling Solutions

Historically, biofouling control has been achieved by exploiting the toxicity of metals, organometals and other similar marine invertebrate biocides and incorporating them in paint matrices to form anti-fouling coatings.

This class of coatings and associated methodology is unacceptable for gliders for a number of reasons.

The use of released organometals to achieve biofouling control is not acceptable for gliders because the density of the coating changes as the metal is released from the paint matrix. This is also true of most nonmetal biocides.

This problem is further exacerbated when using an ablative paint matrix, as is common in most traditional anti-fouling paints.

The traditional anti-fouling paints also often impose occupational hazards to those handling coated equipment. At Rutgers, many of the handlers are young students. Another consideration is that the long-term effectiveness of the paints is limited because the active biocide is eventually all released from the paint matrix over time. This would necessitate the annual removal and recoating of a paint system, which is time consuming and imposes additional occupational and hazardous material issues. Finally, the traditional anti-fouling paints are not transparent.

Other anti-fouling techniques that are sometimes used on oceanographic instrumentation, such as ablative greases containing various pepper extracts, were also evaluated, but they were judged to be unacceptable when evaluated against the performance requirements of long-term effectiveness, durability, occupational safety and constant density.

Biofouling Solutions for Gliders

A newer class of coating that is specifically formulated for undersea instruments (optical or acoustic, for example) and specialized platforms such as gliders has recently emerged and was identified by the Rutgers engineering group as a good candidate for the Scarlet Knight. This coating, ClearSignal™, is a clear, nontoxic, rubber-like coating that resists biofouling because of the nonstick properties of the material itself. The product is a permanent coating that is designed to last for the life of the platform or instrument it is protecting.

The ClearSignal biofouling control system is the product of a joint development effort by Severn Marine Technologies LLC (SMT) and Mercer Island, Washington-based Mid-Mountain Materials Inc. (MMM).

The companies originally developed ClearSignal to coat instruments used in the offshore seismic exploration industry. The product was recently reformulated to accommodate the larger oceanographic research community.

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Coating Selection and Use

After a careful review and evaluation of a variety of biofouling solutions by the Rutgers marine lab, it was determined that the ClearSignal anti-fouling system was the best solution for meeting all of the performance requirements described. It was determined that for this initial implementation of ClearSignal, the yellow main body sections were to be coated. This comprised approximately 90 percent of the Scarlet Knight's surface area. The individual glider sections were sent by Teledyne Webb Research Corp. to the SMT-MMM coating facility in Arlington, Washington, for application of the coating. The coated sections were then sent to Rutgers so that the Scarlet Knight could be assembled and configured for the transatlantic crossing.

Coating Performance

The Rutgers research team documented the performance of the glider anti-fouling coating during its transit through diver inspection and photography in the Azores, as well as inspection upon recovery off the coast of Spain.

In early July, three months into the crossing, Rutgers observed that the glider was having trouble turning and holding its navigation course as instructed. This was the first indication that at least a moderate degree of biofouling was adversely affecting the glider. The control problems became more acute in mid-August, with the Scarlet Knight losing a significant portion of its steering and navigational ability as it headed toward the Azores.

With the journey three-quarters complete and the Scarlet Knight's forward propulsion and control now at a critical state, the Rutgers field service glider team intercepted the glider in late August at its location west of the Azores.

Observations and Actions Taken

An initial inspection of the Scarlet Knight revealed a significant settlement of gooseneck barnacles on specific areas of the glider. It was obvious from the outset that Scarlet Knight was being impeded by the observed barnacle settlement.

The ClearSignal-coated yellow main body sections of the Scarlet Knight were free of all but minor barnacle attachment. The biofouling that did occur was mostly sporadic and consisted of small individual barnacles. It was also noted that some of the sporadic biofouling that occurred on the ClearSignal-coated body were in areas where the biofouling had propagated from the heavily biofouled uncoated sections of the glider.

The glider sections that were not coated with ClearSignal, such as the front-nose-cone pump section aft of the nose cone, connecting seams and the conductivity, temperature, depth (CTD) sensor area had moderate to severe biofouling.

The areas that were most vulnerable and had the highest accumulation of barnacles were the seams between the glider sections, wing rails and the areas on and near the CTD sensor. It is important to note that these areas suffered from severe biofouling as a result of not being coated with ClearSignal and because of the turbulence generated by the glider surface discontinuities in these areas. It is a known phenomenon that barnacles accumulate in these types of low-pressure turbulent areas.

The biofouling noted was cleaned by the divers on site without removing the Scarlet Knight from the water. As reported by the divers, the small degree of biofouling removed from the ClearSignal-coated areas of the Scarlet Knight were removed with almost no effort. The significant barnacle accumulation removed from the areas not coated with ClearSignal required a moderate degree of effort.

After the Scarlet Knight was cleaned, it was given a check for operational soundness and sent back on its way to Spain.

Observations in Spain

The Scarlet Knight performed well on its final leg of the crossing, but did show impediments to its speed near the end of the journey in November and December. The recovery on December 4 provided a second opportunity to assess the glider's vulnerabilities to biofouling and the performance of the ClearSignal solution.

The biofouling settlement observed in Spain was the same species of gooseneck barnacle and was greater in degree and areas of settlement than observed in the Azores. Again, the most vulnerable areas were the body-connecting seam areas, wing rails and CTD areas, the portions of the glider unprotected by ClearSignal and subject to high turbulence. It was also observed that the wing sections were moderately biofouled. Overall, the ClearSignal-treated sections of the Scarlet Knight had little to no fouling settlement. There was, however, moderate biofouling on the ClearSignal-coated area where barnacle settlement had propagated from the vulnerable and uncoated highly biofouled areas of the glider.

"Overall, the ClearSignal-treated sections of the Scarlet Knight had little to no fouling settlement."

As with the cleaning in the Azores, the effort to remove the barnacles from the body-section seams, CTD areas and other nontreated areas of the glider was moderate. The effort required to clean the small degree of settlement on the ClearSignal-coated areas was minimal.

Conclusions

The implementation of the ClearSignal biofouling control coating was integral to the Scarlet Knight's successful and historic Atlantic crossing. The coating system achieved this performance while meeting the important criteria of providing an anti-fouling coating with constant density, constant efficacy over time, optical clarity and long-term durability.

"The coating system met the important criteria of providing an anti-fouling coating with constant density, constant efficacy over time, optical clarity and long-term durability."

The ClearSignal system worked extremely well, as there was little to no biofouling settlement on the majority of the surface area protected with ClearSignal. Where areas of moderate biofouling attachment to the ClearSignal were observed, it was due to the propagation of barnacle settlement from the most vulnerable areas noted.

Since the barnacle settlement occurring on the seams of the glider sections was due to the turbulence generated in these areas and the lack of a biofouling treatment, the prescribed approach for eliminating the biofouling associated with these areas is to tape off these seams to eliminate turbulence and then coat with ClearSignal.

The implementation of additional ClearSignal coating and the turbulence reduction methods noted will significantly reduce the settlement of biofouling in these areas and significantly reduce the propagation of barnacles.

This is especially important as oceanographers seek to extend the duration of glider missions focused on the upper ocean. ■

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Chip Haldeman served as the lead field technician for the Scarlet Knight Atlantic crossing. He is also a scientific research diver and, as such, was responsible for all underwater activities during the glider's deployment, intervention and recovery.

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