

Evaluation of Glider Coatings against Biofouling for Improved Flight Performance

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LONG-TERM GOALS

Autonomous buoyancy-driven gliders are becoming an increasingly important platform for the Navy for semi-continuous oceanographic observations. These observations are central to enhancing ocean model forecasting, underwater communications, underwater imaging, and a host of other applications. In order to provide these functions, it is critical that the flight characteristics be maintained for duration, spatial coverage and navigation. Currently, a number of the glider systems in use suffer in flight performance from biofouling, and this problem is exacerbated if the vehicle spends more time near coastlines or near the surface where there is enhanced biological activity. Here, we propose to leverage an existing ONR biofouling program (Code 34) to examine and evaluate the coatings of the 3 glider types currently in use. These evaluations will be compared to each other as well as the non-toxic coatings being evaluated under the biofouling program. These results have the potential to significantly increase the endurance and performance of gliders with direct benefits to the Navy.

OBJECTIVES

Our objectives are to examine a number of glider materials currently in use and evaluate their fouling (and anti-fouling) potential. The coatings will be evaluated using two assay approaches currently used by the ONR biofouling program to increase fuel/time efficiency for the Navy's active fleet. The final product from this program is to provide the glider users with an evaluation of their coating relative to other gliders and to other coatings. Information will help the current developers further optimize the flight performance of their systems.

APPROACH

The following work plan describe the approach used to meet the preceding outlined objectives. Samples for this proposal will be provided by the glider manufacturers/operators. These will include sections of the hull, couplings, control surfaces and any other outer component that is of concern or has had evidence of significant fouling. Also sent will be materials that have shown resistance to fouling

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as it will be important to show the range of influence. Assessment of these surfaces will include evaluation on laboratory and field scales.

These are an essential part of the down-select process in that laboratory testing allows a rapid assessment of a coating or surface under controlled and reproducible conditions, thus the challenge is not site-specific or seasonal in character. Laboratory-scale evaluation is an important component as these are the controlled conditions used in the ONR's Marine Biofouling program. Furthermore, it allows the different stages of settlement, attachment and fouling release to be studied in detail. This is especially important, as the key to antifouling (ie. weak adhesion and fouling release) necessitates control of the settling stages (spores or larvae), which are not considered in field tests employing panels hung from rafts.

The laboratory experiments consist of five diagnostic tests. The initial test involves a simple assay of possible negative effects of leachate from the emergent coatings. Next, we determine the inherent inductive or anti-fouling capabilities of the coatings with a barnacle cypris larvae settlement assay. After the settlement assay, the settled barnacles are 'grown-out' and the growth rate of barnacles are compared to controls to evaluate any effects the emergent coating may have on health and growth rate of the barnacles. Additionally the coatings are evaluated during this time for their short-term durability in a constantly immersed system. Finally, removal force testing is performed to determine efficacy of the emergent coatings as foul-release surfaces.

Field-testing consists of immersing the glider samples off of the Cal Poly floating test platform in Morro Bay, California, one of ONR's established Marine Biofouling sites. Morro Bay is a cool water, temperate marine environment and thus the fouling community associated with our static test site is different than subtropical and tropical communities. To better track changes in physical parameters at our field site we have installed a water quality array that records every 15 minutes eight water quality variables including temperature, tide, salinity, water velocity, chlorophyll level, nitrate concentration, and turbidity. These data are uploaded to a server through a telemetry system and the data are archived for future use if need be. Researchers can access data online or through direct requests (see www.slosea.org). In addition to understanding the physical environment at our site, we have completely characterized the fouling community by doing extensive surveys. All species recorded in our surveys can be accessed through an on-line database (see www.slosea.org). It should be noted that the equipment array, the invertebrate inventory, and the website resource are all funded through external grants outside of the ONR program.

Samples sent to us are exposed in a rack system that is suspended below a floating dock. Panels are generally exposed for between one to 12 months depending on season and the experiment being conducted. At regular intervals the panels are assayed for percent coverage, water-jet testing, and force gauge removal testing. Percent coverage is calculated by first taking a digital photograph of the panel, and then using digital image analysis to determine the amount of the panel covered by fouling. Water-jet testing is done as outlined by Swain and Schultz (1996), using the water-jet apparatus described therein. The water-jet is trained on the panel, and the pressure is increased incrementally and the type and amount of fouling removed is recorded. Lastly, we use a handheld force gauge to remove barnacles in shear from the face of the panel according to ASTM 5618. The mean force necessary to remove barnacles will be compared among coatings using a standard one-way ANOVA. Although this provides an assessment only for the local natural communities of this temperate site, the Marine Biofouling program is beginning to assess across sites. Swain et al. (2000) found that although the relative performance of coatings at different field sites was similar, there were important and

statistically significant differences in the type and intensity of fouling at different sites and differences in critical removal stress for barnacles between the sites. Current sites include; Pearl Harbor, HI; Indian River Lagoon, FL; Morro Bay, CA; and TMSI, Singapore. In addition, NAVSEA utilizes two sites on the east coast of Florida (Daytona Beach, Miami) for testing or qualifying hull coatings for use by the Navy.

WORK COMPLETED

The first step in the success of this project required participation from the glider manufacturer community. To date we have received material from 3 glider manufacturers. In order to assess the samples quantitatively, we needed multiples of each sample. We also needed various pieces of glider hulls as there are also different coatings on a single glider type. We received 10 different samples from UCSD/Scripps, operating the spray glider. There was one sample from Webb Research Inc., operating the slocum glider. Finally there were three samples from UW (for iRobot), operating the seaglider. For the 14 total samples collected we have 6 replicates for each (only 5 from Webb Research Inc.). Coatings include the following types; Aluminum with Seahawk Mission Bay 4000 Series Zinc Omadine/Zinc Oxide paint, Aluminum with Proline 4800 paint, Aluminum with Proline 4800 paint with Zinc Oxide cream (desitin), Anodized 6061-T6 Aluminum with a duplex seal, Aluminum with Seahawk 4000 with Bio-Boost additive, Nitrile Rubber (SOLO Sleeve bladder), Conap TU-8080 Polyurethane, Conap TU-971 Polyurethane, clear signal coatings, and standard seaglider paint with Kiss Cote applied.

Lab coatings have been prepped and are awaiting batch larvae for testing. This will be in combination with a number of other coatings from the ONR Biofouling Program [i.e. Intersleek900 control (foul release coating)]

Field coatings underwent final preparation work and were deployed September 22, 2010 (Figures 1-3).



Figure 1. Deployment of the hull samples from three glider types (Spray, Slocum, and Seaglider) in the biofouling assessment field site in Morro Bay, CA. Samples will be maintained and periodically assessed over the next 6 months.

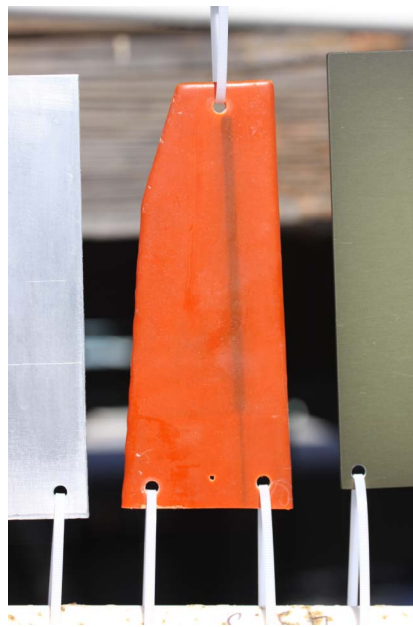


Figure 2. Example hull sample from a spray glider being prepared for deployment in the biofouling assessment field site in Morro Bay, CA. Samples will be maintained and periodically assessed over the next 6 months.



Figure 3. Cal Poly undergrads attach glider hull samples to the frame for deployment in the biofouling assessment field site in Morro Bay, CA. Samples will be maintained and periodically assessed over the next 6 months.

RESULTS

As the samples have recently been received and prepared for field and laboratory studies, initial results are expected in October, 2010.

IMPACT/APPLICATIONS

New generations of marine coatings that are non-toxic and durable are central to the interests of the US Navy, given the increasingly stringent laws limiting the use of toxic paints to control biofouling. This research will assist in the development of non-toxic marine coatings by providing rapid evaluation of the efficacy of the emergent technologies and by improving our understanding of the fundamental mechanisms controlling the performance of elastomeric coatings. Data generated from our work will directly provide better design criteria for meeting the US Navy's need for non-toxic coatings as a more environmentally benign solution to the problem of biofouling.

TRANSITIONS

None to date

RELATED PROJECTS

Marine Biofouling: Community Structure and Surface Interactions Program (Code 34) (PI: D. Wendt)

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PUBLICATIONS

None.

HONORS/AWARDS/PRIZES

None.