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Final Report: A Wave Glider for Studies of Biofouling and Ocean Productivity

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5c. PROGRAM ELEMENT NUMBER
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5e. TASK NUMBER

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13. SUPPLEMENTARY NOTES
The views, opinions and/or findings contained in this report are those of the author(s) and should not contrued as an official Department of the Army position, policy or decision, unless so designated by other documentation.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	15. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON / 19b. TELEPHONE NUMBER
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RPPR Final Report
as of 15-Dec-2017

Agency Code:

Proposal Number: 68951RTREP

Agreement Number: W911NF-16-1-0477

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Report Date: 17-Nov-2017
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Final Report for Period Beginning 18-Aug-2016 and Ending 17-Aug-2017

Title: A Wave Glider for Studies of Biofouling and Ocean Productivity

Begin Performance Period: 18-Aug-2016
End Performance Period: 17-Aug-2017
Report Term: 0-Other

Submitted By: John Breier
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STEM Degrees:

STEM Participants:

Major Goals: STATEMENT OF THE PROBLEM STUDIED
Our long-term goal is to improve biofouling mitigation and thereby increase ocean vehicle endurance, reduce fuel consumption, and reduce carbon emissions. During deployments, vessels encounter a range of planktonic assemblages and ocean environments creating a dynamic relationship between engineered surfaces and ocean life. This instrumentation procurement project focuses on developing infrastructure to better study this process and thereby improve our understanding of this relationship. A Wave Glider outfitted with environmental sensors, and engineered test surfaces was procured to study controls on ocean productivity, plankton distribution, larval settling, and biofouling. We are particularly interested in understanding the role of the environment in determining the rate and nature of biofouling. Our near-term focus will be a study area along the south Texas coast extending to the shelf break. Our long-term plan is to expand our studies to the greater Gulf of Mexico and beyond. This acquisition will allow University of Texas Rio Grande Valley (UTRGV) researchers and our collaborators to apply their expertise in ocean biogeochemistry and larval processes to biofouling.

Liquid Robotics Wave Gliders are wave and solar-powered autonomous surface vehicles consisting of a surface float and a tethered subsurface glider (Hine et al., 2009). The Wave Glider SV3 proposed for this acquisition is the most recent commercial version of Wave Glider and has expanded payload for instrumentation compared with previous versions as well as a combination thruster and rudder for times when active propulsion and navigation are useful. Wave Gliders can passively harvest wave energy for propulsion; the surface float, tether, and glider are tuned for this purpose. The surface float contains control, communications, navigation, and core sensing systems as well as solar panels and rechargeable batteries. There are also multiple mounting locations for auxiliary instruments within the surface float, on the surface float, and on the subsurface glider. Vehicle speed varies with wave height. In relatively calm to slight seas speeds range between 0.25 to 2 knots. Wave Gliders have survived seas with up to 6 m waves and 50 meter per second winds (Manley and Wilcox, 2010; Villareal and Wilson 2014).

Remote vehicle command and control, as well as core data and science telemetry, can be accomplished through both Iridium satellite and cellular modem connections. Wave Gliders have conducted continuous deployments for up nine months; the main limiting factors being component failure and biofouling, which increases vehicle drag and ultimately limits the vehicle's ability to hold course. This Wave Glider is outfitted particularly to study biofouling processes and ocean primary productivity.

BIBILOGRAPHY
Hine, R., Willcox, S., Hine, G., and T. Richardson. 2009. The Wave Glider: A Wave-Powered autonomous marine vehicle. OCEANS 2009, Biloxi, MS, pp. 1-6.
doi: 10.23919/OCEANS.2009.5422129.

Manley, J., and S. Willcox. 2010. The wave glider: a persistent platform for ocean science. In OCEANS 2010 IEEE-Sydney, pp. 1-5.

Villareal, Tracy A., and Cara Wilson. A comparison of the pac-X trans-pacific wave glider data and satellite data (MODIS, aquarius, TRMM and VIIRS). 2014. PloS one 9.3: e92280.

Accomplishments: The specific objective of this project was the acquisition of a Wave Glider autonomous vehicle capable of remote, long-term operation in the surface ocean as part of the DOD HBCU/MI Instrumentation program. This procurement was completed in the spring of 2017. A Liquid Robotics Wave Glider SV3 was procured with surfaces for a biofouling array on the subsurface glider/propulsor and surface float and equipped with an acoustic Doppler current profiler, an optical camera system, and standard sensors for conductivity, water and air temperature, dissolved oxygen, chlorophyll-a fluorescence, wind speed and direction, barometric pressure, and accelerometer based wave parameters. It is also capable of carrying future sampling payloads. The instrument is fully operational.

Training Opportunities: While this was an instrument procurement grant, rather than a science or training grant, the procurement of this instrument has enabled a variety of subsequent training experiences for UTRGV faculty (3), students (3), and staff (1) during this period.

Results Dissemination: Nothing to Report

Honors and Awards: Nothing to Report

Protocol Activity Status:

Technology Transfer: Nothing to Report

PARTICIPANTS:

Participant Type: Technician
Participant: Catheline Froelich
Person Months Worked: 1.00 **Funding Support:**
Project Contribution:
International Collaboration:
International Travel:
National Academy Member: N
Other Collaborators:

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A Wave Glider for Studies of Biofouling and Ocean Productivity

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6. AUTHOR(S)
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13. SUPPLEMENTARY NOTES

14. ABSTRACT
This was an equipment acquisition grant to obtain a Wave Glider autonomous vehicle capable of remote, long-term operation in the surface ocean. The Wave Glider is equipped for biofouling arrays on the subsurface glider/propulsor and surface float, an acoustic Doppler current profiler, an optical camera system, and standard sensors for conductivity, water and air temperature, dissolved oxygen, chlorophyll-a fluorescence, wind speed and direction, barometric pressure, and accelerometer based wave parameters. The procurement of this equipment is complete.

15. SUBJECT TERMS
ONR, fouling, vessels, autonomous vehicles, oceanography

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
					Dr. John A. Breier Jr.
				5	19b. TELEPHONE NUMBER *(Include area code)* 956-882-6625

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A Wave Glider for studies of biofouling and larval population connectivity (HBCU/MI Instrumentation)

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Final Progress Report
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and ONR Code 342, Attn: Linda Chrisey, linda.chrisey@navy.mil

Project Period: 8/18/16 to 8/17/17

1. STATEMENT OF THE PROBLEM STUDIED

Our long-term goal is to improve biofouling mitigation and thereby increase ocean vehicle endurance, reduce fuel consumption, and reduce carbon emissions. During deployments, vessels encounter a range of planktonic assemblages and ocean environments creating a dynamic relationship between engineered surfaces and ocean life. This instrumentation procurement project focuses on developing infrastructure to better study this process and thereby improve our understanding of this relationship. A Wave Glider outfitted with environmental sensors, and engineered test surfaces was procured to study controls on ocean productivity, plankton distribution, larval settling, and biofouling. We are particularly interested in understanding the role of the environment in determining the rate and nature of biofouling. Our near-term focus will be a study area along the south Texas coast extending to the shelf break. Our long-term plan is to expand our studies to the greater Gulf of Mexico and beyond. This acquisition will allow University of Texas Rio Grande Valley

(UTRGV) researchers and our collaborators to apply their expertise in ocean biogeochemistry and larval processes to biofouling.

2. SUMMARY OF THE MOST IMPORTANT RESULTS

The specific objective of this project was the acquisition of a Wave Glider autonomous vehicle capable of remote, long-term operation in the surface ocean as part of the DOD HBCU/MI Instrumentation program. This procurement was completed in the spring of 2017. A Liquid Robotics Wave Glider SV3 was procured with surfaces for a biofouling array on the subsurface glider/propulsor and surface float and equipped with an acoustic Doppler current profiler, an optical camera system, and standard sensors for conductivity, water and air temperature, dissolved oxygen, chlorophyll-a fluorescence, wind speed and direction, barometric pressure, and accelerometer based wave parameters. It is also capable of carrying future sampling payloads. The instrument is fully operational (Fig. 1).

Liquid Robotics Wave Gliders are wave and solar-powered autonomous surface vehicles consisting of a surface float and a tethered subsurface glider (Hine et al., 2009). The Wave Glider SV3 proposed for this acquisition is the most recent commercial version of Wave Glider and has expanded payload for instrumentation compared with previous versions as well as a combination thruster and rudder for times when active propulsion and navigation are useful. Wave Gliders can passively harvest wave energy for propulsion; the surface float, tether, and glider are tuned for this purpose. The surface float contains control, communications, navigation, and core sensing systems as well as solar panels and rechargeable batteries. There are also multiple mounting locations for auxiliary instruments within the surface float, on the surface float, and on the subsurface glider. Vehicle speed varies with wave height. In relatively calm to slight seas speeds range between 0.25 to 2 knots. Wave Gliders have survived

Figure 1. The Liquid Robotics Wave Glider SV3 procured in this project is shown on the right and consists of a surface float and a subsurface glider/propulsor. The glider/propulsor can passively extract power for propulsion from ocean waves. Solar panels and batteries in the surface float provide power for instruments and control computers. The bottom of the float and the wings of the glider/propulsor will be used as biofouling test surfaces.

seas with up to 6 m waves and 50 meter per second winds (Manley and Wilcox, 2010; Villareal and Wilson 2014). Remote vehicle command and control, as well as core data and science telemetry, can be accomplished through both Iridium satellite and cellular modem connections. Wave Gliders have conducted continuous deployments for up nine months; the main limiting factors being component failure and biofouling, which increases vehicle drag and ultimately limits the vehicle's ability to hold course (Fig. 2). This Wave Glider is outfitted particularly to study biofouling processes and ocean primary productivity.

14. BIBILOGRAPHY

Hine, R., Willcox, S., Hine, G., and T. Richardson. 2009. The Wave Glider: A Wave-Powered autonomous marine vehicle. OCEANS 2009, Biloxi, MS, pp. 1-6. doi: 10.23919/OCEANS.2009.5422129

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Villareal, Tracy A., and Cara Wilson. A comparison of the pac-X trans-pacific wave glider data and satellite data (MODIS, aquarius, TRMM and VIIRS). 2014. *PloS one* 9.3: e92280.