Energy producing buoy for strategic applications: Prototype and Testing – Q1 Report

Grant No. HR0011-09-2-0002

Lead Organization: Monterey Bay Aquarium Research Institute
7700 Sandholdt Road
Moss Landing, CA 95039

Technical points of contact: Andrew Hamilton, Ph.D.
Jim Bellingham, Ph.D.
Tel: 831-775-1861/831-775-1731
Fax: 831-775-1646
Email: hamilton@mbari.org; jgb@mbari.org

Administrative points of contact:
Susan Lantis
Grants Office – MBARI
Tel: 831-775-1803/831-775-1788
Fax: 831-775-1620
Email: grants@mbari.org

Project Period: 3/26/2009-3/25/2011

Report Period: 3/26/2009-6/25/2009

Summary

In the first quarter of this project, planning and work has been underway to perform the first at-sea test of a prototype wave-energy extraction device. This prototype is being designed specifically to provide validation of the numerical model that has been developed to study wave-body interactions and wave-energy extraction device concepts. This instrumented platform consists of a surface expression and a submerged plate connected by a spring-damper system. Sensors to measure the force and displacement of the spring damper system along with the motions of the surface expression will allow these measurements to be compared to the model-predicted quantities for the sea-state present on the days of the tests. The tests will be performed on July 13-14, 2009.

Activities

1. Purchased of specialized wave-body hydrodynamics software (WAMIT).
2. Completed the design of the validation test.
3. Component purchase and construction of the validation prototype (on-going).
4. Instrumentation calibration (on-going).

Technical Status and Results

The intent of this planned at-sea test is to provide a validation of the numerical model that has been developed to date. This is important because the expense (cost and time) of running the model to examine the sophisticated concepts such as the heaving foil case is not insignificant. Furthermore, because of the nature of the interaction between the wave-body simulation and the computational fluid dynamics models of the submerged foil, if there are problems or inappropriate assumptions in the wave-body simulation part, the resulting computational fluid dynamics simulations will be worthless.

The planned test recreates the simple case of a cylindrical surface buoy floating on the waves and tethered to a submerged plate 30m below. The tether is not rigid but includes a spring/damper system that allows relative motion to occur between the surface buoy and submerged plate, the amount of power dissipated in the damper system represents the potential power take-off capability of the system. Figure 1 illustrates the set-up. For this validation test, no effort will be made to capture and convert this energy, but the amount dissipated (as heat) will be measured. During the tests the force and extension of the spring/damper element of the system will be measured and logged, along with the incoming wave-spectra, buoy motions, and submerged plate motions.

The spring/damper system is constructed from industrial hydraulic components, a 72” long linear ram will provide compliance and be plumbed to a system of accumulators and valves that will provide a spring effect (force proportional to displacement) and a damping effect (force proportional to velocity). Because it is difficult to construct a linear spring and damper system from these hydraulic components, the actual characteristics of the spring/damper system will be measured in the lab before the test. These actual spring and damper functions will then be included in the numerical model. In this way the results will provide a good measure of the models ability to predict the behavior of the system, including non-linear elements.

Two submerged elements are planned to be tested, a flat plate and a sphere, each of about 1300lbs weight in air. The flat plate case is closer to our needs relative to further work with a submerged foil. However, there are potentially significant hydrodynamic effects experienced by a flat plate that can’t be modeled without computational fluid dynamic work. For this reason the test plan also includes a submerged sphere (28” diameter) as the submerged element. This geometry is predictably modeled by simple functions and will allow validation of the wave-body interaction part of the model without contamination by potential un-modeled hydrodynamic effects of the flat plate. Results will be logged with both of these submerged elements over the planned two days of testing.

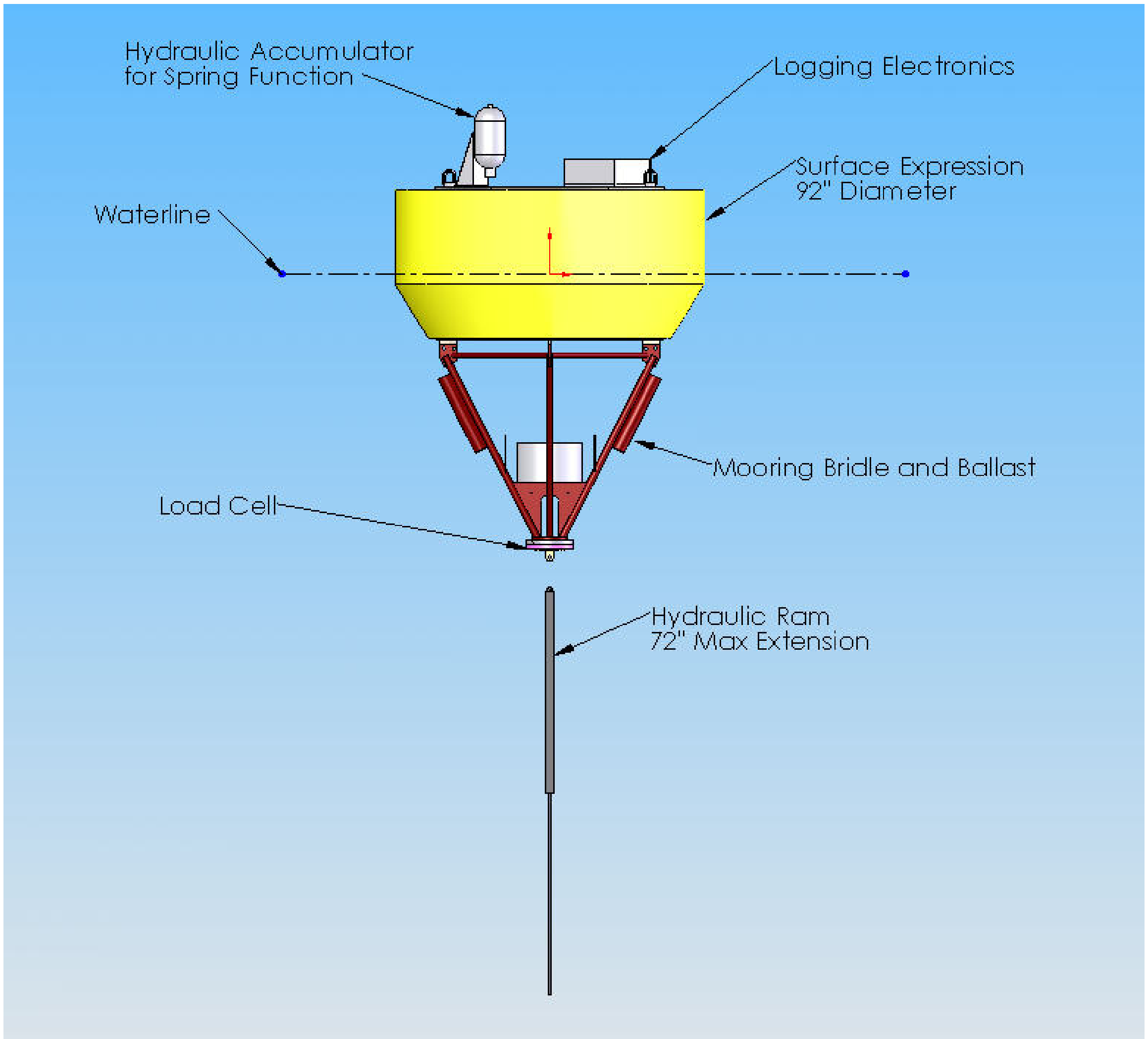

Figure 1: Surface expression and hydraulic cylinder acting as spring/damper system. Flat plate or sphere will be connected and submerged at a depth of 30 meters.

Budget and Spending

As of 6/17/2009, $23,688 has been spent out a budgeted $626,637.00. Attached to this report is the MBARI budget status report for this project.

Plans

In the next quarter of this project the validation test outline here will be complete. The validated numerical model will then be expanded and used to investigate the behavior of the various wave-energy extraction and station-keeping concepts that have been proposed. The submerged foil concept continues to be a leading candidate and the computational fluid dynamics modeling of the foil behavior will be combined with the wave-behavior model to explore the possibilities of this concept.

Attachments

1. MBARI Grant Status Report
2. Electrical and hydraulic schematics of planned test equipment.