Surf Zone Mapping and Sensor System

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LONG-TERM GOALS

The long-term goals of this ONR Small Business Innovation Research (SBIR) Program Phase I and Phase II (started August 2005) effort are to develop a Surf Zone (SZ) bottom drifter measurement system that is relatively invulnerable to effects of breaking waves and that utilizes near bottom currents to provide drifter locomotion without using its own power as well as to transition the technology to support nearshore research, including model validations, and SZ naval operations. Several drifters deployed in a SZ would form a mobile SZ measurement and mapping system.

OBJECTIVES

Objectives are:

(1) harnessing SZ currents (e.g., undertow and rip currents) to move drifters throughout and generally offshore of the SZ where they would return to the surface for data relay and optional reuse;

(2) measuring key data such as bathymetry, waves, and surf; and

(3) tracking drifter locations so that these data can be gridded for research and operational applications. Based on naval feedback to the Phase I research, an additional objective is to develop a riverine system variant that would measure currents, bathymetry, and other data as it is transported.

APPROACH

The approach is to design a barely negatively buoyant spherical drifter that is large enough (e.g., volleyball to basketball size) to accommodate sensors, a tracking system, and a system control and data analysis microprocessor as it rolls over the bottom due to SZ currents. The concept employs new micro Inertial Measurement Units (IMU's) for inertial tracking with acoustic tracking updates considering SZ acoustic limitations. Drifters would be manually deployed beyond the swash zone and would surface outside of the SZ where data would be relayed by radio or satellite. A riverine system variant would likely surface intermittently for GPS position updates (i.e., no acoustic tracking).

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WORK COMPLETED

During Phase I, techniques were investigated and developed to track drifters using new micro IMU's with acoustic tracking updates considering SZ acoustic limitations (e.g., noise and bubble attenuation). A preliminary design that considered size, weight and power limitations was developed. Preliminary data analysis methods to provide SZ bathymetry and wave information were programmed and tested with simulated drifter tracks using SZ bathymetry from the Field Research Facility (FRF), Duck, NC.

Figures 1 and 2 show external and cut-away views of the SZ bottom drifter as it was designed in Phase I. Colors are used only to allow distinguishing components (e.g., the inner and outer hemispheres). The inner sphere is gimbaled loosely within the outer sphere to maintain the acoustic tracking hydrophone roughly upright as the barely negatively buoyant drifter rolls on the bottom.

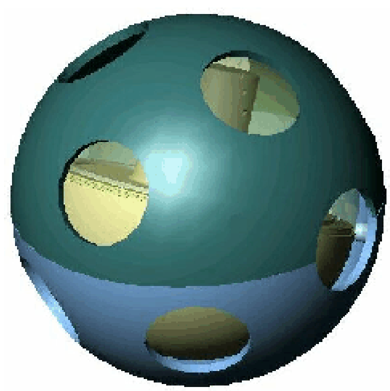

Figure 1. External View of SZ Drifter.

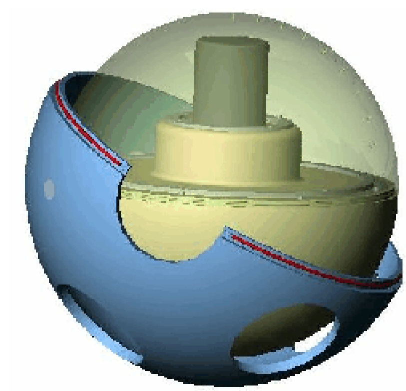

Figure 2. Cut-Away View of SZ Drifter.

During a short Phase I option, two simplified prototype drifters were built. One was used in the field at Eglin Air Force Base, FL, during March 2005. Because the cost ceiling precluded collecting field data with a complete system, a design was developed for a mechanically similar test drifter, but one without tracking instrumentation, environmental sensors, and data relay capabilities. During August 2005, a Phase II contract was awarded to develop a complete prototype system, field test the system to prove feasibility of the technology, and to participate in field research experiments and naval exercises.

RESULTS

Development of the preliminary design proved that the system is feasible from mechanical and electrical engineering perspectives. Use of preliminary data analysis methods with simulated drifter tracks and FRF SZ bathymetry data showed that wave and bathymetry information in pressure data could be separated to provide non-directional wave spectra and derived wave parameters as well as bathymetry data along drifter tracks. Three gridding programs were tested with various numbers of drifter tracks to show that gridded bathymetry needed for most applications (e.g., SZ maps, inputs into models) can be extracted from track data. Preliminary analysis of spatial sampling variability effects on estimation of SZ bathymetry data indicated that suitable data can likely be obtained.

An important result was that the limited field tests with a simplified drifter confirmed that it could roll over the bottom due to longshore currents and undertow with undertow moving it offshore. The tests were performed under low wave conditions (wave heights approximately 0.5m and somewhat greater). A nearshore trough up to approximately 1.8 m deep occurred before an offshore bar about 15 m offshore where the water depth decreased to about 1.2 m. After initial tests to adjust drifter ballast, two tests (20 min and 30 min durations) were conducted during which the drifter was moved along the trough by longshore currents and then transported offshore over the bar. These tests confirmed that the basic drifter design is sound and that such a drifter is transported by wave-induced nearshore currents. The inner sphere was observed to move reasonably independently of the outer sphere and to remain approximately upright most of the time while the outer sphere rotated during transport by near-bottom currents. Processing of the horizontal and vertical accelerometer data showed that the inner sphere was approximately stabilized as the outer sphere rolled on the bottom. Figures 3 through 7 illustrate the sequence of steps used to deploy a drifter, manually track it, recover it, and download data from it. Figure 8 shows the drifter size compared to a person.

Figure 3. Preparing to Deploy the Drifter.

Figure 4. Deploying the Drifter by Hand in the SZ.

Figure 5. Tracking the Drifter using a Kayak.

Figure 6. Recovering the Drifter using a Kayak.

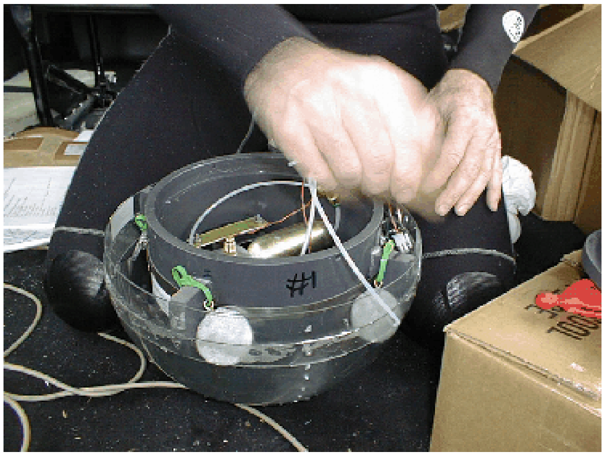

Figure 7. Downloading Drifter Data and Preparing for the Next Deployment.

Figure 8. Drifter Size Compared to a Person.

IMPACT/APPLICATIONS

The importance of Very Shallow Water (VSW) and the Surf Zone (SZ), VSW/SZ, for naval littoral operations is well-known. Both ocean dynamic conditions (e.g., waves, surf, longshore currents, rip currents, and undertow) and bathymetry may vary significantly in space and time. Bathymetry is especially important as a key input to numerical models used to determine dynamic conditions. Nearshore numerical models have become quite advanced so that bathymetric uncertainties are an error source that could be minimized.

The technology would also support nearshore processes research in general. Emphasis will be placed on the system being portable and easily operated so that SZ data can be collected when and where it is needed rather than only at the few locations where nearshore processes experiments usually are conducted. Because the system will be able to measure near bottom properties, including currents, it would be useful for sediment transport studies. ONR suggested that a drifter's drag might be adjusted so that its path would be similar to drifting of near bottom biota. An application of major public interest would be system use for rip current studies and development of better rip current predictions. Each year rip currents cause over 100 drownings and account for about 80% of all beach water rescues nationally.

TRANSITIONS

Initial transitions would be use of the developed technology to: (1) support naval littoral VSW/SZ operations, and (2) assist in ONR sponsored field research toward better understanding of SZ processes. Field research results also would support naval operations. An example is validating SZ numerical models that could be used operationally. There are a number of potential sponsors and users. Government organizations include: the Commander-Naval Meteorological and Oceanographic Command (CNMOC), the U.S. Naval Oceanographic Office (NAVO), components of the Naval Sea Systems Command (NAVSEA) such as the Coastal Systems Station (CSS), Naval Special Warfare (NSW) Groups, ONR, and the U.S. Army Corps of Engineers (USACE).

RELATED PROJECTS

Research performed at the Scripps Institution of Oceanography (Professor Robert Guza), the Naval Research Laboratory – Stennis Space Center (Dr. Todd Holland, Dr. Nathaniel Plant, and Dr. William Schmidt), and the Woods Hole Oceanographic Institution (Dr. Steve Elgar) is related. A near-surface GPS-tracked SZ drifter was developed recently by a Scripps / Woods Hole team (Schmidt et al., 2003). Dr. Holland's group is involved in extracting data from SZ video data. Plans call for performing Phase II field tests at the relatively nearby Eglin Air Force Base, FL, where they have installed instrumentation. Dr. Plant has performed recent research enabling analysis of spatial sampling variability effects on estimation of SZ bathymetry data (e.g., Plant et al., 2002). Collaboration will also be sought to participate in future field experiments at the FRF, Duck, NC, and some Phase II field tests could be performed at the FRF.

REFERENCES

Earle, M.D., Surf Zone (SZ) mapping and sensor system, ONR SBIR Phase I Final Report, Neptune Sciences, Inc., 57 pp., 29 October, 2004.

Earle, M.D., Surf Zone (SZ) mapping and sensor system, ONR SBIR Phase I Option Final Report, Neptune Sciences Division, Planning Systems Inc., 12 pp., 31 March 2005.

Schmidt, W.E., B.T. Woodward, K.S. Millikan, R.T. Guza, B. Raubenheimer, and S. Elgar, A GPS-tracked surf zone drifter, *J. Atmospheric and Oceanic Tech*., 20, 1069-1075, 2003.