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14. ABSTRACT

This report describes the acquisition of a REMUS AUV (manufactured by Hydroid Inc.) and initial efforts made using it map hydrographic fields in coastal and marine environments. To date, we have found that REMUS' capability to make repeated, unattended surveys of temperature, salinity, and chlorophyll a provides a valuable addition to traditional fixed instrumentation. However, so far we have had problems obtaining good ADCP data, especially in very shallow water (< 3m). In contrast, descriptions of the bottom topography derived from sidescan sonar data have added a new dimension to our ability to understand small-scale (< 1km) flow behavior.

15. SUBJECT TERMS
Autonomous underwater vehicle, hydrography, coastal hydrodynamics, mixing, coral reefs

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FINAL REPORT

Grant #: N00014-01-1-0464

PRINCIPAL INVESTIGATOR: Prof. Stephen Monismith

GRANT TITLE: Acquisition of a Remus Auv for Autonomous Coastal Flow Mapping

AWARD PERIOD: 04/01/01 - 12/01/03

OBJECTIVE: This was a DURIP award to provide funds towards the purchase of a REMUS AUV for use in studies of coastal and estuarine flows. The objective intended for REMUS is as a tool to enable us to characterize the flow on scales of 10 -1000 meters in a region in which we are studying smaller scale flow phenomena like turbulent mixing.

APPROACH: After acquisition of REMUS in April 2003 (the purchase from Hydroid Inc took approximately 1 year to complete), we have deployed REMUS as part of 3 field experiments between April 2003 and July 2004:

(1) In very shallow water in Franks Tract (an open water region of the Sacramento/San Joaquin Delta), REMUS was used to map bottom characteristics (via side-scan sonar) and to record tidal variations in salinity, temperature, and chlorophyll a over most of 2 tidal cycles. This work was supported by the California Bay Delta Authority as part of a project investigating hydrodynamic effects on benthic grazing.

(2) REMUS was used in the Conch Reef area off Key Largo in an exploratory mode to carry out hydrographic and side-scan mapping of the reef environment near the NOAA Aquarius Habitat. This work was done with support from the NURC at UNC Wilmington.

(3) REMUS is currently being used off the South Shore of Oahu (July 12 to July 21) to map small scale (10's of meters) dye plumes over rough topography and in the presence of surface waves. This work is a collaboration with Dr. Geno Pawlak of the University of Hawaii and is supported by internal Stanford funds and by an ONR award to Pawlak.

ACCOMPLISHMENTS: In each case, we have collected extensive data sets on hydrographic variability and bottom topography. For example, in the Florida data set, we could clearly see changes in bottom roughness (sand to coral to

sand and seagrass) as REMUS executed a transect starting at a deep reef location, passing over the reef crest and into Hawk Channel a shallow (ca. 5m) channel lying between the Keys and the reef tract. In all cases we have found that REMUS does an excellent job at mapping temporal and spatial variability in temperature, salinity, chlorophyll and in our plume experiments, Rhodamine WT dye.

We have become reasonably proficient at deploying and recovering REMUS in a variety of environments. In this regard, we have determined that one of the key aspects of working with REMUS is to be able to efficiently deploy the acoustic transponders used for underwater positioning. Unfortunately, as "early adopters", we have also experienced the difficulties inherent to the transition of a research technology (REMUS as built and operated by WHOI) as opposed to a commercial technology (REMUS as built and sold by Hydroid).

Perhaps the biggest problem we have encountered so far has been that the ADCP data has not been of very good quality (but, we have yet to do anything with the new Hawaii data). For example, for the Franks Tract data, the ADCP bottom track velocities were significantly in error, an effect that may be due to problems with bottom tracking in very shallow water. In Florida, we saw evidence of the bias problem Derek Fong and I recently published in J. Atmos. Ocean. Tech. (Vol. 21, No. 7, pp. 1121–1128). The Hawaii data will provide an important test of the ADCP since it will result in ca. 30 hours of ADCP transects in a region in which we have 4 ADCPs deployed on the bottom.

All of the three data sets are currently being analyzed and will form parts of the PhD theses of 3 PhD students: Ms. Nicole Jones, Ms. Kristen Davis, and Mr. Ryan Lowe. In each case, the REMUS data significantly enhances the value of other measurements (e.g. fixed ADCPs). The Hawaii plume data in particular is unique and valuable given the Navy's interests in being able characterize small scale processes in near-shore waters. This experiment is an outgrowth of work sponsored on plumes by the ONR CSME program (directed by Dr. Keith Ward). Since acquiring REMUS, many of our new proposals for work have involved REMUS, in particular proposals aimed at synthesizing AUV data with small scale hydrodynamic models of coastal regions.

CONCLUSIONS: The REMUS AUV is a powerful tool that is at the same time quite challenging to use effectively. Simply

put, if some attention is given to how it is used and for what purpose, REMUS offers the user the ability to make unique measurements. However, in terms of its utility for Naval operations, it would appear that a more careful examination of its limitations (e.g. bottom tracking in shallow water) should be made.

SIGNIFICANCE: With proper attention to how they work and what they can be used for, REMUS-like AUVs will eventually revolutionize nearshore coastal oceanography. The data sets described above contain information that could not have otherwise been obtained.

PATENT INFORMATION: none

AWARDS INFORMATION: none

PUBLICATIONS AND ABSTRACTS: none yet

SPECIAL INFORMATION FOR DURIP AWARD:

Type of equipment: REMUS AUV
Manufacturer of equipment: Hydroid Inc.
Cost of equipment: $362,000 (incl. OS 200 CTD, Turner Designs SCUFA chlorophyll a fluorometer, Turner Designs Cyclops Dye fluorometer and training) - DURIP grant was for $300,000 - the rest came from Stanford University funds
Quantity: 1