Deep Autonomous Gliders for the "Autonomous Ocean Sampling Network II' Experiment

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LONG-TERM GOALS

We aim to provide cost-effective ways to gather physical and bio-physical data over an ocean region with sufficient temporal and spatial resolution to resolve and define mesoscale features using autonomous instruments so that surveillance could be extended indefinitely.

OBJECTIVES

The prototype autonomous underwater glider 'Spray' was designed to have superior range and duration but has been tested very little. The Autonomous Ocean Sampling Network II project needed cost-effective ways to gather hydrographic and velocity data with which to initialize and constrain data assimilating ocean models with which to forecast ocean conditions around Monterey Bay. Our objectives, therefore, were to operate five Spray within roughly 100 km of shore near Monterey to (a) detect operational weaknesses and demonstrate the capability of the vehicles and (b) to provide suitably located hydrographic profiles to as deep as 700 m and directly measure current transport in real-time in order to feed the project's two data assimilating models.

APPROACH

This effort was a cooperation between the AOSN program and a project inside the NOAA-sponsored Consortium on the Ocean's Role in Climate (CORC), which is developing autonomous underwater gliders for climate monitoring. For AOSN II we were to construct 3 new Spray gliders while CORC would provide two. Collectively, the AOSN program established an array of 5 lines running approximately 100 km offshore from Monterey Bay upon which Spray gliders were to take data. This array is shown in Figure 1. Spray data was to assist in initializing and constraining the offshore portions of the AOSN's two data-assimilating modeling projects, which were led by Dr. Yi Chao of JPL and Prof. Allan Robinson of Harvard. Dr. David Fratantoni of WHOI was to operate a larger fleet of shallower-water gliders closer to shore.

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14. ABSTRACT
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15. SUBJECT TERMS

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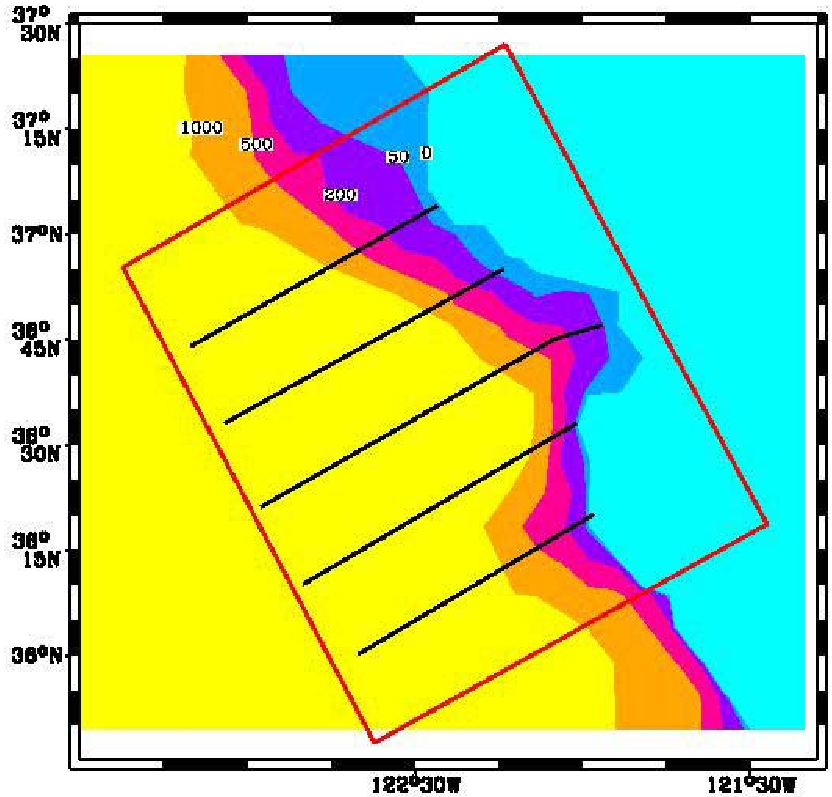

Figure 1. Bathymetry of the region around Monterey Bay is shown with contour breaks at 0, 50, 200, 500 and 1000 m. Red rectangle represents the approximate extent of the high-resolution portions of the data-assimilating models used in AOSN II. The five offshore lines represent the target sections along which Spray gliders were meant to operate.

Spray was designed and constructed by Jeff Sherman and the staff of the Instrument Development group of Scripps Institution of Oceanography under earlier AOSN funding. It is described by Sherman et al. (2001) and compared with the other two extant gliders by Davis et al. (2002). The latter shows Spray to have greater operating depth and range than the "Slocum-Electric" glider and to be simpler and less expensive than "Seaglider." Spray changes its buoyancy to alternately dive to depths down to 1500 m and then ascend to the surface. At the surface, Spray determines its position from GPS and establishes two-way communication with shore through Iridium satellites in order to report observations and receive updated mission commands. As the glider rises and falls it uses wings to convert vertical velocity into forward motion at speeds near 30 cm/s.

For AOSN II, Spray would, in the absence of competing currents, be able to run the length of one of the 100-km lines in about 4 days. Data would be relayed to shore after every dive, automatically quality-controlled immediately, and manually quality-controlled approximately once each day. Automatically checked data would be available to the modeling teams within a few minutes of the glider surfacing.

WORK COMPLETED

All elements of the approach outlined above were accomplished without significant deviation. The Instrument Development Group completed a design to transition communication to Iridium satellites, field tested a modified Spray near La Jolla, CA, and constructed and tested five gliders in time for deployment 10 days before the AOSN intensive study month of August 2003. A team of four deployed the gliders and the five gliders operated continuously for the month while one person was engaged in data quality control. At the end of the month a team of four recovered the gliders in two day-trips after they had been flown to a collection zone near Moss Landing, CA.

A final round of data quality control and comparison with model forecasts lies ahead.

RESULTS

To data (one month after the field trial ended), three results of the project are clear.

First, Spray technology has matured to the operational state and we have shown that the instrument's capabilities make possible cost-effective long-term regional observing systems using that technology.

Second, comparison with the Slocum glider has shown the strengths of the two designs. The combination of lithium batteries (rather than alkaline cells), lower drag, and more succinct data transmission allow Spray to operate for months instead of weeks for Slocum, greatly reducing the manpower and ship time required to maintain a glider array. The Slocum is designed to turn rapidly, permitting it to sample in much shallower water where Spray might be stranded. The Precision Measurement Engineering conductivity sensor used on Spray was subject to step changes in calibration, apparently caused by impact with biological particles. A more stable conductivity cell and/or redundant measurements will be needed for future operations in Monterey Bay.

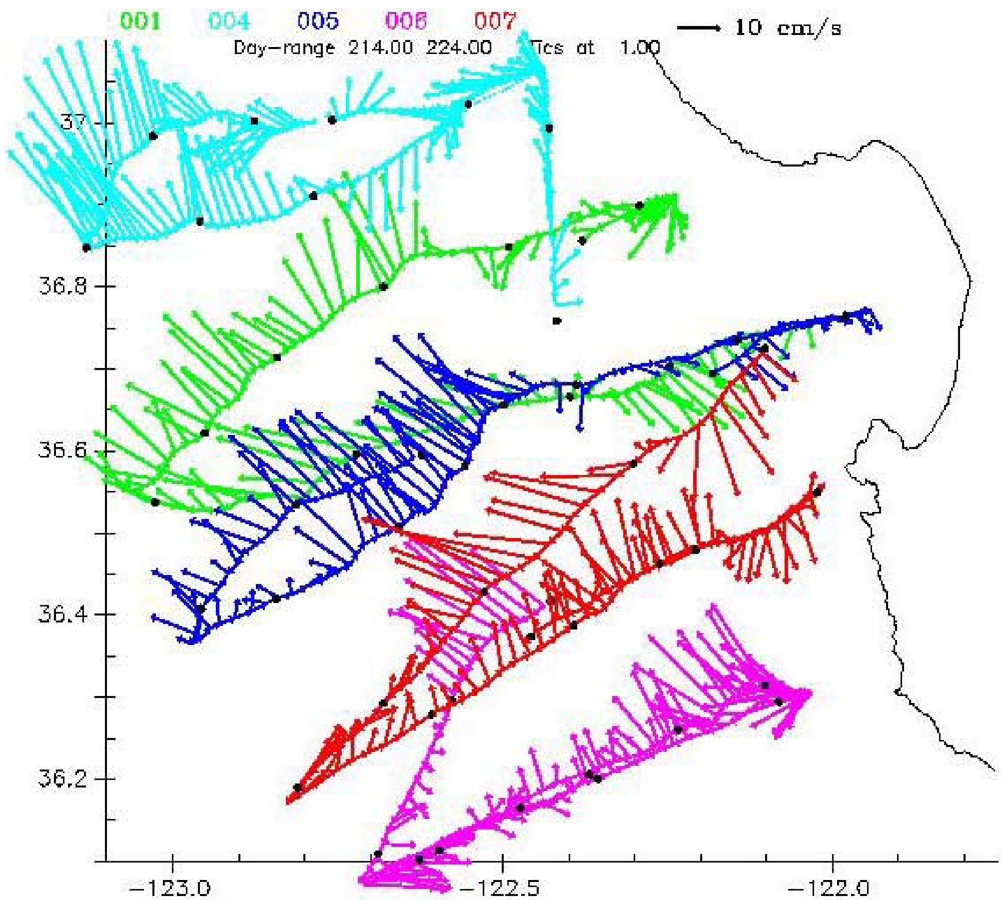

Figure 2. Average velocity between 0 and 400 m depth offshore from Monterey Bay. Each color represents a different glider. The period covered, 2-12 August 2003, is at the start of the experiment so that the lines, other than the deep blue one for SN 5, show the glider dispersing from their deployment 36.7°N, 122°W. Offshore currents to the northwest are the California Undercurrent, which frequently exceeds 20 cm/s. Equatorward flow is apparent closer to shore.

Third, the direct velocity observations made by Spray disclosed a surprisingly strong California Under-Current. Most Spray dives were to 400 m depth and the average current over this depth range was deduced from the difference between dead-reckoning and navigation. Figure 2 shows the average velocity between the surface and 400 m measured between 2 August and 12 August 2003. The figure shows a strong California Undercurrent flowing to the northwest dominating the offshore flow with speeds up to 25 cm/s. Because these currents are comparable to the glider's forward speed, the array is significantly distorted from the ideal shown in Figure 1.

IMPACT/APPLICATIONS

The successful operations of Spray indicate that this underwater glider is ready for operational use. Limited operating speeds require daily, or at critical times hourly, updates of the mission parameters to adapt to currents, and sensor longevity remains an issue, but Spray (and other gliders) open new possibilities for cost-effective autonomous sampling of the ocean.

RELATED PROJECTS

This project was related to all AOSN II projects, but the closest connections were with:
Development of a Monterey Bay Forecasting System Using The Regional Ocean Modeling System (ROMS) – Yi Chao – N00014-03-1-0208

Aerial Surveys of the Atmosphere and Ocean off Central California – S.R. Ramp, J.D. Paudan, W. Nuss, and C. A.Collins – N0001403WR20002, N0001403WR20006

Use of a Circulation Model to Enhance Predictability of Bioluminescence in the Coastal Ocean – I. Shulman, L. Rosenfeld, J. Paduan, D. McGillicuddy - N00014-03-WX-20882 and –20819, N00014-03-WR-20009 and N000140210853

Autonomous Ocean Sampling Network II (AOSN II): System Engineering and Project Coordination – J.G. Bellingham and P. Chandler – N00014-02-1-0856

Autonomous Ocean Sampling Network II: Assessing the Large Scale Hydrography of the Central California Coast – Margaret A. McManus and Francisco Chavez – N000140310267

An Autonomous Glider Network for the Monterey Bay Predictive Skill Experiment / AOSN-II – D.M. Fratantoni – N000140210846, N00014-03-1-0736, N00014-02-1-0846

Development of a Regional Coastal and Open Ocean Forecast System: Harvard Ocean Prediction System (HOPS) – A.R. Robinson – N00014-97-1-0239

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