

# Operational Glider Deployments for Navy Applications

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## LONG-TERM GOALS

1. Use gliders to meet the Navy's operational needs for environmental characterization.
2. Establish concept of operations for using different types of gliders in the same exercise.
3. Enable all aspects of glider operations from NAVOCEANO.

## OBJECTIVES

1. Learn Navy's needs for environmental characterization and develop glider sampling plans that most effectively meet those needs. Plan glider operations to provide measurements that help minimize uncertainty in the appropriate Navy model products.
2. Collaborate with the other University glider groups: Scripps Institution of Oceanography (Spray), Rutgers University (Slocum) and Woods Hole Institution of Oceanography (Slocum), to coordinate operations and control during Navy exercises.
3. Train NAVOCEANO personnel in glider launch, piloting, and recovery operations.
4. Provision NAVOCEANO as glider basestation, with responsibilities for command and control, data receipt, processing, quality assurance and archiving.

## APPROACH

A Navy ASW exercise was selected as an opportunity to deploy all three varieties of gliders in support of NAVOCEANO's environmental characterization requirements.

The exercise was planned for an area spanning a shelf break, with depths from less than 100m to greater than 1000m. A strong boundary current that flows roughly parallel to the shelf break dominates the exercise operating area. Depth-averaged currents in the boundary current are typically at or above a glider's maximum horizontal speed through the water.

A sampling plan was devised to provide density profiles in the area of greatest uncertainty in Navy acoustic propagation models. Plans matched gliders to environments best suited to their capabilities. Two Rutgers University (RU) Slocum electric gliders, depth-rated to a maximum of 200m, profiled on

the continental shelf out to the 200m isobath while one Scripps Institution of Oceanography (SIO) Spray, rated to 600m for this exercise, and one University of Washington (UW) Seaglider, rated to 1000m, profiled in the deeper waters offshore of the 200m isobath.

Gliders were launched upstream of the exercise area, with tracks planned to sample repeatedly across the region of interest while being advected downstream by the depth-averaged currents. Exercise plans required that all gliders be out of the operating area by the start of the exercise, but allowed for the possibility of returning upstream of the operating area upon completion of the exercise. This was planned offshore (Spray and Seaglider) or inshore (Slocum) of the boundary current, contingent on the location and strength of that current.

The Slocums were owned and operated by Dr. Scott Glenn and his colleagues in RU's Coastal Ocean Observation Lab. The Spray was owned and operated by Dr. Russ Davis and his group at SIO. The Seaglider was owned and operated by personnel from the UW Applied Physics Laboratory.

## **WORK COMPLETED**

Four gliders (two Slocums, one Spray and one Seaglider) were deployed as scheduled about one week prior to the start of the exercise.

Hurricane Katrina imposed a change of plan on shoreside operations, however. Glider command and control, data receipt, processing, quality assurance, and rewriting into standard message formats were performed at each glider operator's institution, rather than at NAVOCEANO. Following precedent established during previous glider deployments in Navy exercises, data messages were sent via email to specified Navy recipients, including NAVOCEANO, and NPMETOC (San Diego and Yokosuka).

Coordination of glider operations was accomplished by direct communications (email or telephone) between the glider groups. All glider profile and velocity data were immediately and automatically shared between the operators, as well as sent to the Navy as described above.

All four gliders were successfully recovered within a few days of the completion of the exercise.

Seaglider completed 184 dives over 16.5 days, and profiled from the surface to depths as shallow as 206.9m and as deep as 1014.6m. It was flown at about twice its normal speed through the water, both to stem the strong boundary current and to improve spatial and temporal resolution of the profiles. Profiles of conductivity, temperature, and dissolved oxygen were obtained. Depth-averaged currents were inferred from glider horizontal speeds (calculated from observed vehicle pitch and buoyancy) and surfacing positions. Seaglider had a 100% data return rate and expended about 40% of its battery pack.

## **RESULTS**

Successful completion of the exercise demonstrated the ability of three University glider groups to collaborate effectively to execute a sampling plan, adapting in real-time to rapidly changing oceanographic and operational conditions. All gliders were able to exit the downstream side of the exercise operating area prior to the specified deadline.

Seaglider demonstrated its ability to attain horizontal speeds of  $40 \text{ cm s}^{-1}$ . Seaglider was able to follow predetermined survey tracks in water deeper than 200m where depth-averaged currents were less than its maximum horizontal speed. It profiled successfully across a strong boundary current, while minimizing distance traveled downstream. Seaglider was making significant progress upstream on the offshore side of the current immediately prior to recovery.

Gliders were launched and recovered with a minimum of University glider team personnel onboard the launch platform. Two glider team members worked with the ship's crew to launch the four gliders. Only one glider team member was aboard for the glider recoveries; NAVOCEANO personnel played a major role in the launches and recoveries. The ability to perform launch and recovery operations with a minimum number of University personnel demonstrates the feasibility of the field component of a NAVOCEANO-operated glider fleet.

## **IMPACTS/APPLICATIONS**

As the exercise has only recently been completed, specific analysis of the impact of the glider profiles on the quality of NAVOCEANO's model products has not yet been done.

It has been shown that gliders provide a cost-effective, controllable way to autonomously sample the water column in an energetic operations area. Multiple gliders of different types leverage each design's intrinsic advantages to improve sample density in the areas of interest.

The success of the glider participation in the exercise, and particularly the collaboration of the three University glider teams, has a positive impact on the plan to transition operational command and control of gliders to NAVOCEANO. The experience gained by working together will inform the effort to build NAVOCEANO a common command and control interface for the three types of gliders. Continued field operations also refine the needs for improved glider physical robustness, and for simple, adaptable launch and recovery aids.

## **RELATED PROJECTS**

ONR Glider Consortium/Technology Transfer Initiative. This ONR program is designed to provide NAVOCEANO with infrastructure and support necessary to successfully operate its own fleet of gliders. The program will perform tasks whose definition and focus has been improved by participation in the recent Navy exercise: improve the physical robustness of the existing gliders, improve techniques and equipment for launch and recovery, provide a common command and control interface for the three types of gliders.