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COOL

by Cliff Bekkedahl

"Cool" seems to be this generation's "hip" response to anything—indeed, everything—that's O.K. or better (when you get beyond the range of "better," then "awesome" takes over). Be that as it may, if you really want to see cool, then get up on <www.rucool.org>. Here you'll find Rutgers University's Coastal Ocean Observation Laboratory (COOL).

At the campus in New Brunswick N.J., COOL is the focal point for the operation of a squadron (eight) of underwater robotic gliders called Slocum gliders which are created and produced at a company called Webb Research Corp in Falmouth Mass. [see insert].

These gliders, as the specs indicate, are easily handled and can be launched and recovered from ships or small craft, and I predict that before long, they will be air-dropped by helo or slow-moving aircraft. The torpedo-shaped vehicle carries a small electric pump to introduce or discharge water from small ballasting tank(s). This determines the buoyancy of the glider. When water is taken in, the vehicle descends and the stubby wings stabilize and control a gliding descent. When the glider reaches its programmed depth, the pump reverses and expels water, and the glider starts its ascent. Reaching the surface, the process is reversed, and the glider begins to descend again. A sensor package in the glider does its work, which can vary depending on the mission. For example, the glider's sensor can measure water temperature at varying depths, salinity, chlorophyll or organic content of the water and other water characteristics. The robot glider describes a saw-toothed pattern, up and down while moving horizontally through the water. In a thirty- to forty-day mission a glider cycling to a depth of 300 feet and returning to the surface can traverse a distance of 400 to 600 kilometers.

PHOTO COURTESY OF WEBB RESEARCH INC.

The Slocum Glider is easily handled from a small craft.

Four times in the course of a 24-hour period—about every six hours or so—when the glider comes to the surface, it makes a satellite phone call to COOL at Rutgers and dumps its data collected since its previous report. This data is instantly analyzed and programmed for display and then broadcast on the Internet for use by any interested party worldwide. While doing its data dump, the glider's navigational system connects with GPS and adjusts its course for travel over the next six hours. Built-in monitors can detect malfunctions in the robot glider and email COOL for help.

Rutgers scientists—a cool bunch of guys and gals from many disciplines—recently deployed a robot glider off the coast of Antarctica. Nowhere on earth are water and weather conditions more prone to extremes. This was an acid test of the integrity and durability of this system. It succeeded beyond all expectations. In less than a month of operation the robot glider phoned home more than 1,300 casts. By comparison, twelve years of previous shipboard research in the area produced only 1,600 casts.

PHOTO COURTESY OF WEBB RESEARCH INC.

COOL Squadron of Slocum Glider

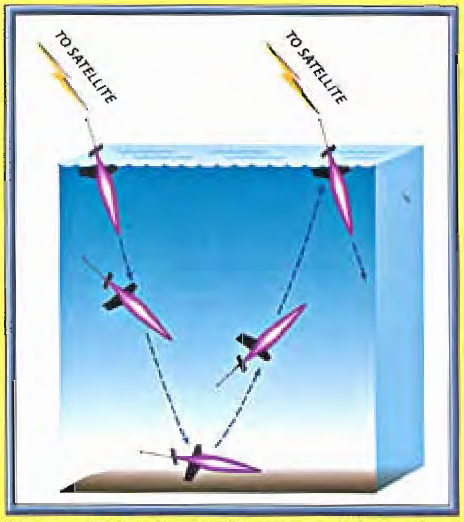
It is currently estimated that there are about 79 of these Slocum gliders in the hands of scientists the world over but mostly in U.S. universities and oceanographic laboratories like Scripps and Woods Hole. All users share data collected on the Internet, and the potential of this relatively inexpensive data collecting technology for advancing all of the ocean sciences is unprecedented.

Looking further into the undersea robot technology, one sees more sophisticated vehicles with solar powered or other self-contained propulsion systems. An autonomous underwater vehicle called *Endurance*, built by Stone Aerospace, a Texas-based company, is being readied to explore under ice-covered bodies of water, such as Lake Vostok, in Antarctica.

Clearly the technology is proven and the future of autonomous underwater vehicles is breathtaking. Their employment will hasten the horizontal alignment of the ocean sciences, and nowhere is this more evident than at COOL where scientists from a broad spectrum of disciplines, mechanical engineering, marine biology, oceanography, computer science, physics and meteorology jointly plan and execute robotic glider missions in ocean reaches the world over.

At a briefing of this writer at COOL at Rutgers, the enthusiastic faculty and graduate students present in the operation center described a typical Slocum glider mission using a real-time example of a mission currently under way. A glider had been launched just south of Cape Cod and was programmed to follow a southerly course along the Atlantic coast to a terminus point off the coast of New Jersey.

One of the mission specs was to take readings that measure the presence and health of phytoplankton, which is an essential in the marine life food chain. This information would be of value to federal and state fisheries authorities and, ultimately, to fisherman searching for concentrations of feeding fish. Only hours earlier the glider had entered the east-west shipping lanes to New York and European ports, and the staff was concerned that the glider might be surfacing in this heavily trafficked shipping lane. All were relieved when the anticipated call from the glider revealed that its position was south of the lanes, as programmed. With instant communications via satellite any where in the world, the staff at COOL can manage the glider, alter its mission and movement and respond to emails from the



Slocum Glider "swims" in saw-tooth pattern

glider that report malfunctions. Ask if the operation center was manned around the clock to monitor glider surfacing reports, everyone grinned and said "No way." Some one or two would have the after-hours and night duty, and they keep their laptops or home computers online to the operations center. If a robot failed to report in a reasonable time or if it emailed with a problem, this info would be signaled to the duty person who could either fix the problem or call cohorts to decide on a course of action.

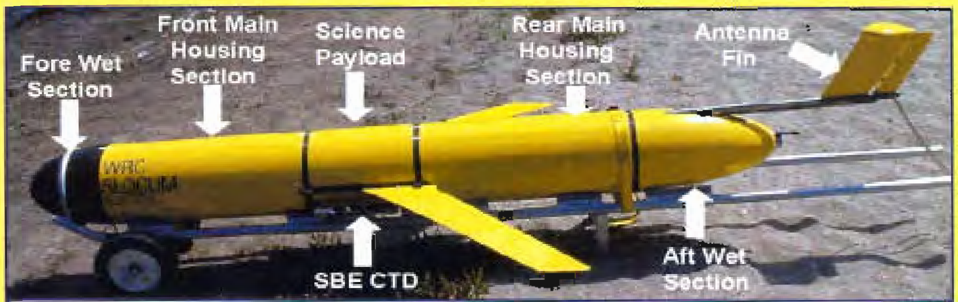
What's next? Probably bigger robots, longer missions, deeper probes, larger sensor packages, aerial launching and retrieval and more robots in more places, more often. Indeed, one topic mentioned as we talked of the future was the development of a professional cadre of AUV operators planning and executing missions as required by ocean scientists from every discipline.

Readers of *The Polar Times* and APS members should have little difficulty imagining the value and rich scientific rewards to be attained by further operation of AUVs in the cold, stormy and ice covered waters north and south of sixty degrees latitude. Intensive operations with multiple launchings and retrievals will require a mother ship or some sort of aerial recovery unit(s). However, obvious factors, such as stand-off capability, low risk to personnel and equipment and the ability to launch, retrieve and service multiple units, will reap vast amounts of oceanographic data at drastically reduced costs. And just as we are seeing major advances being made in the field of unmanned aircraft and space vehicles, the autonomous underwater vehicle will take a leading role in exploration and scientific investigation of the oceans that cover seventy percent of the world's surface. ❑

PHOTO COURTESY OF WEBB RESEARCH INC.

Slocum Glider on surface, ready to dive.

*For more information about the Slocum Glider, visit the following web sites: **www.rucool.org** and **www.webbresearch.com/slocum** (be sure to type two "b's" for the latter).*



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SLOCUM AUTONOMOUS UNDERWATER VEHICLE GLIDERS

Type: COASTAL or DEEP
Objectives: Versatile, maneuverable deployment with 1-2 people
Flexible payload
Energy: 240 "C"-size Alkaline Batteries
Range: 600 - 1500 km
Endurance: 15 - 50 days
Two versions: (4 to 200m) or (40 to 1000m)
Navigation: GPS Waypoints, Magnetic Compass
Communication: RF Modem, Iridium, ARGOS, Acoustic Modem
Speed: .04 m/s (0.77 knot) Average Horizontal

Gliders are unique in the AUV World

Forward propulsion is created by varying vehicle buoyancy. Wings and control surfaces convert vertical force into forward velocity so the vehicle glides downward when denser than water, and glides upward when buoyant. Gliders require no propeller and operate in a vertical saw-tooth trajectory.

The principal advantages of Autonomous Underwater Vehicle Gliders (AUVGs) are:

- Suitable for long-range and endurance, if low to moderate speed is acceptable.
- The saw-tooth profile is optimal for both vertical and horizontal observations in the water column.
- Regular surfacing enables GPS and two-way communication, no other navigational aids are required and the system is very portable.

Navigation and Flight

The Slocum Battery Glider dead reckons to waypoints, inflecting at set depths and altitudes based on a programmed mission file. As set by the mission, the Glider periodically surfaces to communicate data and instructions and to obtain GPS location. Any difference in dead reckoning and GPS position is attributed to current, and that *offset* is compensated on the subsequent segment.

Present Sensors:
- Acoustic Modem
- Altimeter
- Bathyphotometer (bioluminescence)

Optical Backscatter
- Optical Attenuation
- Scattering Attenuation Meter
- Radiometer
- Oxygen

Conductivity, Temperature, Depth
- Fluorometer
- Hydrophone & Towed Arrays
- PAR sensor
- Spectrophotometer (red tide detection)

Conceived by Douglas C. Webb and supported by Henry Stommel and others, the class of Slocum Gliders is named after Joshua Slocum, the first man to single-handedly sail around the world.

It is a uniquely mobile network component capable of moving to specific locations and depths, occupying controlled spatial and temporal grids. Driven in a sawtooth vertical profile by variable buoyancy, the glider moves both horizontally and vertically.

The long range and duration capabilities of the Slocum gliders make them ideally suited for subsurface sampling at the regional scale. The Slocum gliders can be programmed to patrol for six weeks at a time, surfacing to transmit their data to shore while downloading new instructions at regular intervals, at a substantial cost savings compared to traditional surface ships.

The small relative cost and the ability to operate multiple vehicles with minimal personnel and infrastructure will enable small fleets of Gliders to study and map dynamic (temporal and spatial) ocean features around-the-clock and calendar. ❑