The August 2003 Autonomous Ocean Sampling Networks (AOSN-II) experiment utilized a heterogeneous group of 21 underwater vehicles with widely varying capabilities to investigate physical and biological processes associated with coastal upwelling along the central California coast. Central to this effort were two fleets of high-endurance autonomous underwater gliders operated by the Scripps Institution of Oceanography and the Woods Hole Oceanographic Institution. Gliders are torpedo-shaped winged vehicles which maneuver slowly through the ocean in a sawtooth-shaped trajectory. At preprogrammed intervals the vehicles surface to determine their geographic position, transmit collected data, and receive new instructions from a shore-based control system via Iridium satellite phone. During the month-long experiment a total of 15 gliders occupied more than 10,000 km of horizontal trackline in Monterey Bay and vicinity and collected more than 12,000 vertical profiles of temperature and salinity, chlorophyll fluorescence, optical backscatter, and PAR.

The ONR-sponsored Autonomous Ocean Sampling Network (AOSN) program is an ambitious effort to bring together novel robotic vehicles with advanced ocean models to improve our ability to observe and predict the physical and biological state of the ocean. The AOSN-II field program was performed in Monterey Bay from mid-July to early September 2003. A total of 21 autonomous underwater vehicles (AUVs) and a variety of in situ and remote instrument systems were used to observe the evolution of upwelled coastal upwelling processes and their biological consequences. The focus of this field program was the upwelling plume generated south of Pt. Año Nuevo during periods of strong northwest winds. Two complete upwelling / relaxation cycles were observed during the experiment. Fifteen gliding AUVs were operated during AOSN-II by the Scripps Institution of Oceanography (SIO) and ten by the Woods Hole Oceanographic Institution (WHOI). While the two glider types share many operational characteristics and equivalent scientific payloads, each was developed for specific types of oceanographic investigation. For example, the SIO "Spray" vehicle is capable of multimeasure blue-water surveys to depths as great as 750 m. In contrast, the Webb Research Corp. vehicle operated by WHOI is better suited to short-term operations in shallow coastal environments. The overall survey plan was designed to best utilize these operating characteristics, with the WHOI gliders occupying long cross-shore transects and the SIO gliders performing high-resolution surveys within Monterey Bay and near Pt. Año Nuevo.

The most significant operational difficulties faced were sensor biofouling and premature vehicle recovery by commercial fishing vessels. All of the gliders were remotely operated using Iridium satellite phones. Telemetered measurements were assimilated in near-realtime by two independent numerical ocean prediction systems.

### Table 1: Operating Parameters

<table>
<thead>
<tr>
<th>Glider Type</th>
<th>Vehicles Deployed</th>
<th>Profiles Collected</th>
<th>Dive Duration (Hours)</th>
<th>WHOI Data Volume (bytes)</th>
<th>Maximum Depth (meters)</th>
<th>Minimum Depth (meters)</th>
<th>AOSN-II Reliability Score (%)</th>
<th>Expected Reliability Score (m)</th>
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</thead>
<tbody>
<tr>
<td>WHOI</td>
<td>10</td>
<td>11,491</td>
<td>2</td>
<td>13,082</td>
<td>492</td>
<td>10</td>
<td>1.14</td>
<td>21.45</td>
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<tr>
<td>SIO</td>
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<td>2,875</td>
<td>2.5 - 5</td>
<td>408 - 750</td>
<td>750</td>
<td>75</td>
<td>35.42</td>
<td>150</td>
</tr>
</tbody>
</table>

![WHOI and SIO GLider Observation Profiles](image)

Five SIO gliders collected hydrographic and vertically-averaged velocity data along five cross-shore sections offshore of Monterey Bay. Gliders were deployed for 35-42 day continuous survey operations. Most dives were to 400 m with one dive per day to 750 m. Intermittent biofouling of conductivity and optical sensors was noted. Data transmission consisted of approximately 620 bytes every 2.5 hours.

Ten WHOI gliders collected hydrographic and vertically-averaged velocity data along five fixed circular transects spanning the Ano Nuevo upwelling plume and performed adaptive sampling experiments using multivehicle clusters. Dives were to 280 m or 5 m above the bottom. The relatively short endurance of the WHOI vehicles required frequent recovery and redeployment operations, and several vehicles were hit and/or prematurely recovered by commercial fishing vessels. Data transmission consisted of approximately 75 kilobytes every 2 hours.

### Figure 1: Glider Observations

- **Left:** WHOI glider observations of 0-400 m vertically-averaged velocity and 0-39 m temperature. Each panel corresponds to five dives of glider survey time. Note the large-scale northeastward flow at 20-35 cm/s offshore of Monterey Bay.

- **Right:** Two cross-shore hydrographic sections obtained by WHOI gliders. The section on the left was obtained during a period of sustained wind relaxation. Note the relatively warm and fresh surface conditions, the moderate chlorophyll concentration, and the generally northwest 0-200 m averaged velocity. The second section, obtained during the peak of an upwelling event, exhibits the cool and salty surface conditions corresponding to recently upwelled water and accumulated chlorophyll concentrations along the edges of the upwelling plume. ASRIR SSV images corresponding to the glider surveys are shown at lower right of each panel.

### Figure 2: Glider Instrumentation

- **Top:** WHOI vehicles collected hydrographic data using a combination of conductivity, temperature, and oxygen sensors. Gliders were instrumented with an Iridium transceiver for near-realtime data transmission.

- **Bottom:** SIO vehicles collected similar data using a combination of conductivity, temperature, and oxygen sensors. Gliders were instrumented with a Iridium transceiver for near-realtime data transmission.

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