Using an Autonomous Underwater Vehicle to Map and Sample a Subsurface Oil Plume in the 2010 Gulf of Mexico Oil Spill

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Outline

• Introduction of MBARI Dorado AUV with 10 water samplers ( gulpers).

• Dorado AUV’s deployment at 13 km to the southwest of the Deepwater Horizon wellhead for making high-resolution surveys and acquiring water samples in a suspected subsurface oil plume.

• A peak-detection algorithm for the AUV’s gulpers to capture water samples with peak hydrocarbon signals in the subsurface oil plume.

• Summary
MBARI Dorado AUV Deployed on NOAA Ship Gordon Gunter Cruise GU-10-02
MBARI’s Dorado AUV with 10 Gulpers
Dorado AUV’s Sensors at the Gulf of Mexico

<table>
<thead>
<tr>
<th>Variables</th>
<th>Sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature, Salinity</td>
<td>Dual Sea-Bird Electronics SBE3 temperature and SBE4 conductivity sensors, using SBE25 conductivity, temperature, depth (CTD) board sets</td>
</tr>
<tr>
<td>Pressure</td>
<td>Paroscientific Digiquartz 8CB4000-I High Pressure Intelligent Depth Sensor, 0-4000 m range</td>
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<tr>
<td>Density</td>
<td>Derived from temperature, salinity and pressure using the MATLAB seawater analysis toolbox from CSIRO</td>
</tr>
<tr>
<td>Dissolved oxygen concentration</td>
<td>Sea-Bird SBE43 oxygen sensor</td>
</tr>
<tr>
<td>Colored Dissolved Organic Matter (CDOM) fluorescence</td>
<td>WETLabs ECO-FL CDOM fluorometer 370 nm excitation; 460 nm emission</td>
</tr>
<tr>
<td>Optical backscattering at 420 nm</td>
<td>HOBI Labs HydroScat-2</td>
</tr>
<tr>
<td>Optical backscattering at 700 nm</td>
<td>HOBI Labs HydroScat-2</td>
</tr>
<tr>
<td>Chlorophyll fluorescence at 700 nm (420 nm excitation)</td>
<td>HOBI Labs HydroScat-2</td>
</tr>
</tbody>
</table>
Dorado AUV Launch/Recovery on Ship Gordon Gunter
Dorado AUV Survey Tracks

CF (volts) on sawtooth transects btn 900 m and 1200 m depths (plan view) in AUV Mission 2010.154.01
Subsurface Oil Plume Measured by the AUV

Temperature (°C) | Salinity (psu) | CDOM (mg m⁻³) | $b_420$ (10⁻³ m⁻¹)
4.75 5 5.25 | 34.92 34.94 | 5 10 | 1 3 5
Above background, based on fluorometric CDOM data

* Subsurface Oil Plume Structure

Plume Intensity (mg m$^{-3}$)
Subsurface Oil Plume Structure

1 June 2010
ROV images < 0.5 km
SW of wellhead
Camilli et al. (2010)
Subsurface Oil Plumes Found in Other GoM Cruises and Studied in Laboratory Experiments

- Subsurface hydrocarbon plumes below 1000 m depth to the southwest of the Deepwater Horizon wellhead were also identified in (Camilli et al., 2010), (Diercks et al., 2010), (Hollander et al., 2010), (Parsons et al., 2010).

- Laboratory experiments have shown that a horizontal mixture of dispersed oil droplets and water forms at the “plume trapping height” where the buoyancy flux and the ambient stratification reach a balance (White et al., 2010, Socolofsky et al., 2010).
An Algorithm for Capturing Peak-Signal Water Samples Using an AUV

Peak depth detected: “Ready to trigger.”

Triggering at corrected depth

Depth delay

Layer of high signal

Low-pass filter
Capturing Peak-Signal Water Samples Using an AUV

Capturing Peak-Signal Water Samples Using an AUV
Summary

• On 3 June 2010, at 13 km to the southwest of the Deepwater Horizon wellhead, we deployed the MBARI Dorado AUV to make high-resolution surveys and acquire water samples in a suspected subsurface oil plume.

• At the survey site, we developed a peak-capture algorithm for the Dorado AUV’s 10 gulpers to capture water samples at CDOM fluorescence peaks in a horizontally oriented oil layer.

• Synoptic mapping + targeted sampling by an AUV provides for an effective approach for studying subsurface hydrocarbon plumes.
Acknowledgments

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