Field testing of the Nereus network

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Prior Work: Portable Mass Spectrometer for Metabolic Gas Measurements¹

- 2.5 cm linear cycloidal analyzer
- Membrane inlet in various configurations
- Linux operating system
- 12 volt, 20 watt power requirement
- Direct predecessor to Nereus underwater mass spectrometer
- 1. Hemond, H.F. 1991. A backpack-portable mass spectrometer for measurement of volatile compounds in the environment. *Rev. Sci. Instrum.* <u>62</u>(6): 1420-1425.





Figure 14. CH₄ Profiles



 CH_4 Concentration (μM)

Problem Statement: Create capability of autonomous measurement of 3-D, transient distributions of chemicals in lakes and the ocean

- Chemical identification and quantification
- Localization
- Data acquisition and networking

Rationale for system configuration

- Maximum underwater mobility->AUV
- General ability to measure volatile chemicals->Mass Spectrometer
- Real-time communications->Hybrid acoustic and radio-based networking

System Components

- Odyssey II autonomous underwater vehicle
- Nereus cycloidal underwater mass spec
- Buoys for networking, supplemental measurements, future navigational aids
- Shore station for control, data display, archiving
- Chase boat/shore station combined function





AUV

- Odyssey II, 2m LOA, ~200 kg
- Free-flooding outer hull
- 3 m/s, 2000m max depth, 8 h endurance
- 2 kwh Li polymer battery
- Crossbow AHRS, Teledyne DVL
- WHOI Micromodem, Freewave SS radio





Nereus mass spectrometer^{1,2}

- Identical cycloidal MS and electronics
- Glass pressure housing->mid-ocean depth
- Free-flooding, unheated membrane inlet
- 16-bit A/D and D/A controller
- PC-104/TSLinux/IAIRA control software
- 1. Hemond, H.F. 1991. A backpack-portable mass spectrometer for measurement of volatile compounds in the environment. *Rev. Sci. Instrum.* <u>62(6)</u>: 1420-1425.
- 2. Hemond, H. F., and R. Camilli. 2002. NEREUS: Engineering concept for an underwater mass spectrometer. *Trends in Analytical Chemistry* 21(8):526-533



Network Buoys

- PC-104/TSLinux/MOOS¹ operating system
- WHOI Acoustic Modem²
- 802.11b radio (Orinoco Gold wi-fi card)
- Thermistor string, Hydrolab, GPS, METS
- Custom MOOS drivers and TX/RX processes
- 1. P. Newman, http://www.robots.ox.ac.uk/%7Epnewman/MOOSDocumentation/index/htm
- 2. 2. Freitag, L., Grund, M., Singh, S., Partan, J., Koski, P., Ball, K., The WHOI Micro-Modem: An Acoustic Communications and Navigation System for Multiple Platforms," in *IEEE Oceans Conference*, Washington D. C. 2005



Temperature of UML waters at Buoy N location, 09/25/06



'Shore Station'

- Laptop running Ubuntu Linux, MOOS
- Freewave SS radio plus 802.11b
- Custom MOOS processes
 - Network logging
 - Subtracker/Mission editor
- Operate from shore or chase boat



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Summary

- System meets major objectives
 - Satisfactory localization and tracking
 - Real-time reporting of chemical data, surfaced and submerged
 - Launch/recover from ordinary ramps, transport in small van
 - Operate with 2+ people from small (14') boat
 - Many off-the-shelf components
- Future needs/ongoing work:
 - Provide ability to alter mission when vehicle is underwater
 - Add LBL navigation capability for longer missions
 - Likely prefer heated inlet for strongly thermally stratified waters
 - Desire better model for acoustic propagation in stratified waters
 - Next generation AUV O(100kg) displacement

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