Probing Marine Biogeochemistry with *in situ* Mass Spectrometry

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Underwater Mass Spectrometry and Marine Biogeochemistry

• Underwater Mass Spectrometry Primer
• Strengths, Weaknesses, and Field Experiences
• Overcoming Weaknesses: Technological Future Directions
• Future scientific applications
Why *in situ* Mass Spectrometry?

- Why *in situ*?

- Field-Tested Systems
  - *Technical University Hamburg - Harburg*
  - *USF - COT*
  - *MIT/WHOI*
  - *AWI*
  - *University of Hawaii*
  - *Harvard/MBARI*

- >25 publications since 1999
Underwater Mass Spectrometry Primer

Harvard ISMS System
Underwater Mass Spectrometry Primer

• Membrane Inlet Mass Spectrometry
  • Membrane Diffusion
  • Dissolved Volatiles

• Wide Range of Target Analytes
  • Analytes < 300 amu
  • Common Dissolved Gasses
  • Volatile Organic Compounds (VOCs)
Deploying an *in situ* MS

Photo: U. Washington Regional Scale Nodes
Deploying an *in situ* MS
Deploying an *in situ* MS

Harvard ISMS Sampling a Hydrothermal Chimney; Photo: ROV Quest
Strengths of the Harvard ISMS

• Strengths of the *in situ* MS (ISMS)
  • *Ease of use*
    • Simple Operation
    • Robust
    • Field Tested
  • *Open Access*
  • *Broad Applicability*
    • Environmental
    • Analytical
  • *Real-Time Data*
Field Experiences from Hydrothermal Vents

Diffuse Flows at the MAR: Photo: ROV Quest
Field Experiences from Hydrothermal Vents

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Mid Atlantic Ridge Deployment 2016

Hoer et al. unpublished data
Weaknesses of the Harvard ISMS

- Weaknesses of \textit{in situ} MS
  - Membrane variability
  - Response Time
  - Fluid flow rate
  - Power Consumption

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Overcoming Weaknesses

“Flux Integrator” in Lau Basin; Photo: ROV ROPOS
Future Directions
Long Term Deployments

- Power and Communications
  - *Cabled Observatories*

- Redundant Systems

- *in situ* Calibration
  - *Calibration Solutions*
  - *Metal Carbides*

‘El Gordo’; Photo: ROV ROPOS
Long Term Deployments: Cabled Observatory

Long-Term Deployment ISMS at the ‘El Gordo’ OOI RSN; Photos: ROV Jason
Autonomous Underwater Vehicle Deployments

- Payload Size
- Power Requirements
- Response Time

AUV Sentry; Photo: Ryan Siebert
Other Deployment Platforms

- Reactive Sampling Mooring
- Benthic Rovers
- Cast CTD Rosette from Ships

MBARI Benthic Rover; Photo: MBARI
Underwater Mass Spectrometry and Marine Biogeochemistry

• Strengths, Weaknesses, and Field Experiences
• Overcoming Weaknesses: Technological Future Directions
  • Careful Calibrations
  • Technological Updates and Adjustments
• Future scientific applications
  • (More) Long Term Deployments
  • (More) AUV Deployments
  • Different Vehicles
  • Reactive Sampling Platforms
Questions?