TECHNOLOGIES FOR DEEP SEA RESEARCH

DESSC NEW USER WORKSHOP
DECEMBER 2014

OUTLINE

- *“Standard” Technologies* – tools maintained by NDSF
- *“Emerging” Technologies* – developed by scientists/engineers in context of specific project
  - future adoption by NDSF?
- *Developing and Designing Technologies* for Deep Sea Research
- Questions/Discussion

'TECHNOLOGY SHOULD MAKE OUR LIVES EASIER'

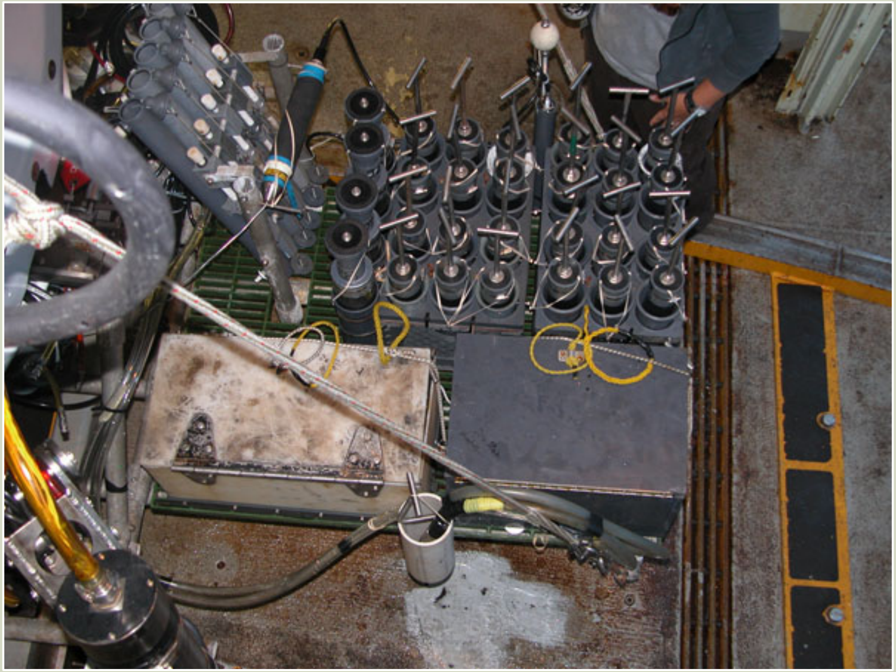
- Goal of technology is to facilitate scientific activities:
  - Sampling/Collecting
  - Measuring
  - Analyzing
  - Imaging/Documenting
  - Communicating
  - Incubating/Preserving

"STANDARD" TECHNOLOGIES

- Commonly used equipment on deep sea vehicles for scientific application
- Generally maintained, installed, made available by NDSF
- Typically very robust
- Probably started as 'experimental' before being widely adopted and taken on as 'mission critical' by NDSF

COLLECTION: BIO/GEO/CHEM

Bio Boxes



Scoop Nets

COLLECTION: BIO/GEO/CHEM

Slurp Samplers

Hydraulically pumped

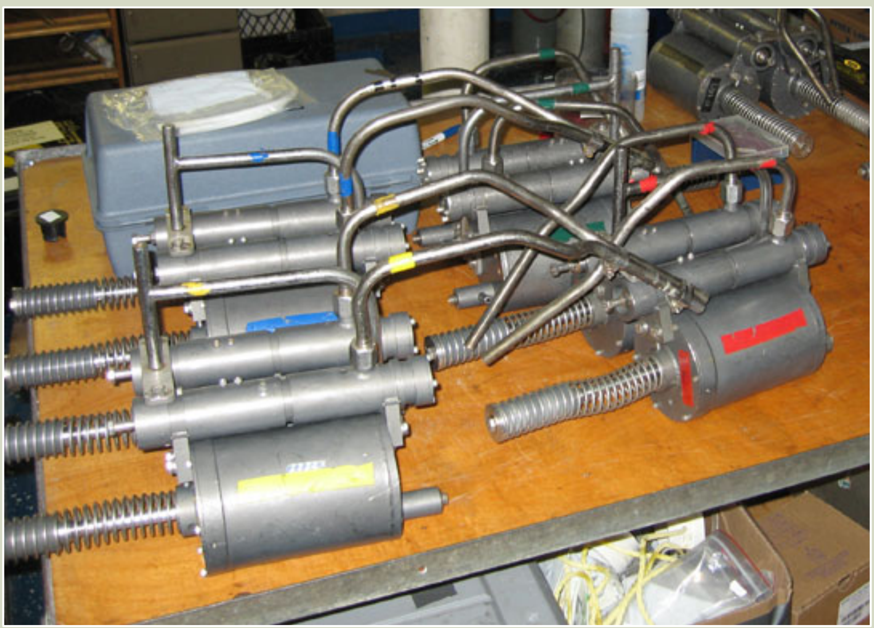
Multi-chamber

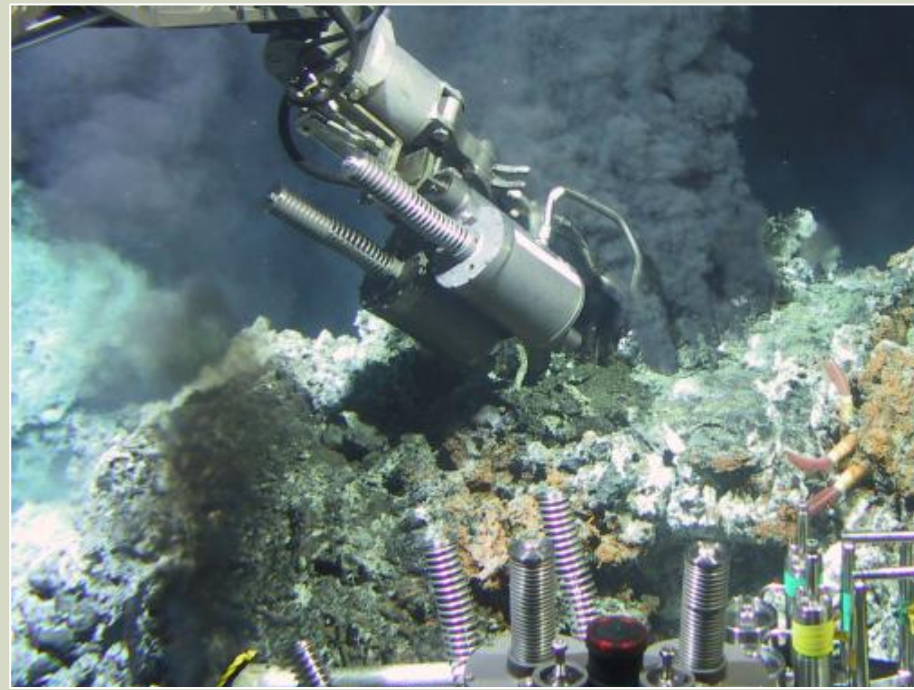
Single-chamber

COLLECTION: FLUID SAMPLING

"Major" Samplers

Pairs of 760ml syringe barrels
Max T 400°C
Temp probe in nozzle via ICL





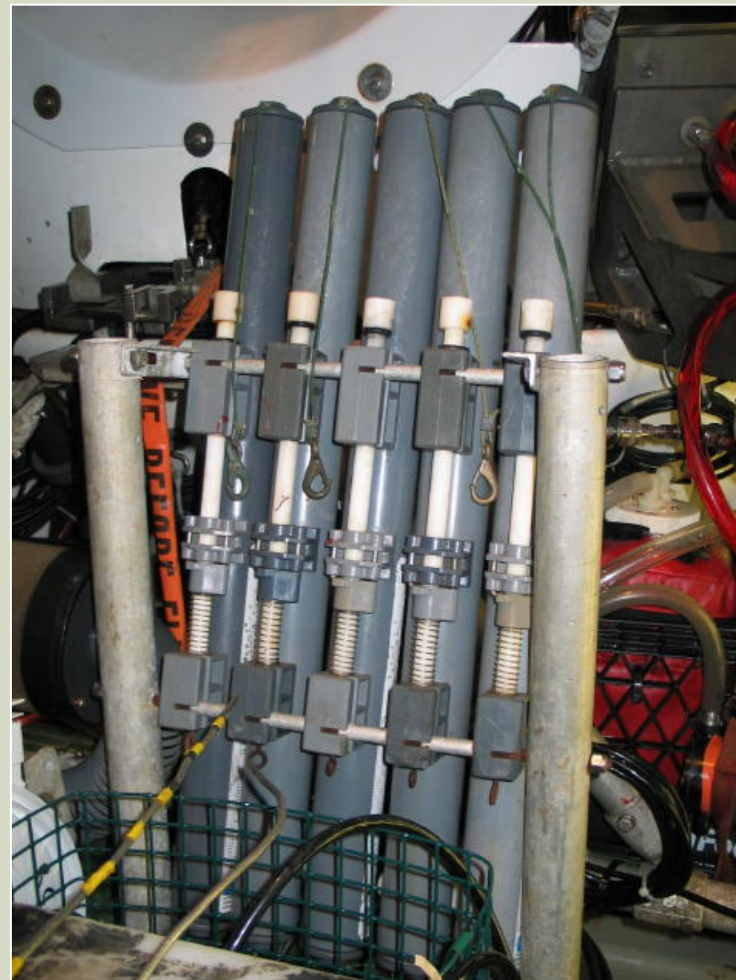
Not for gas-tight sampling

COLLECTION: FLUID SAMPLING

Niskin Samplers

Rack of 5, 1-liter PVC samplers

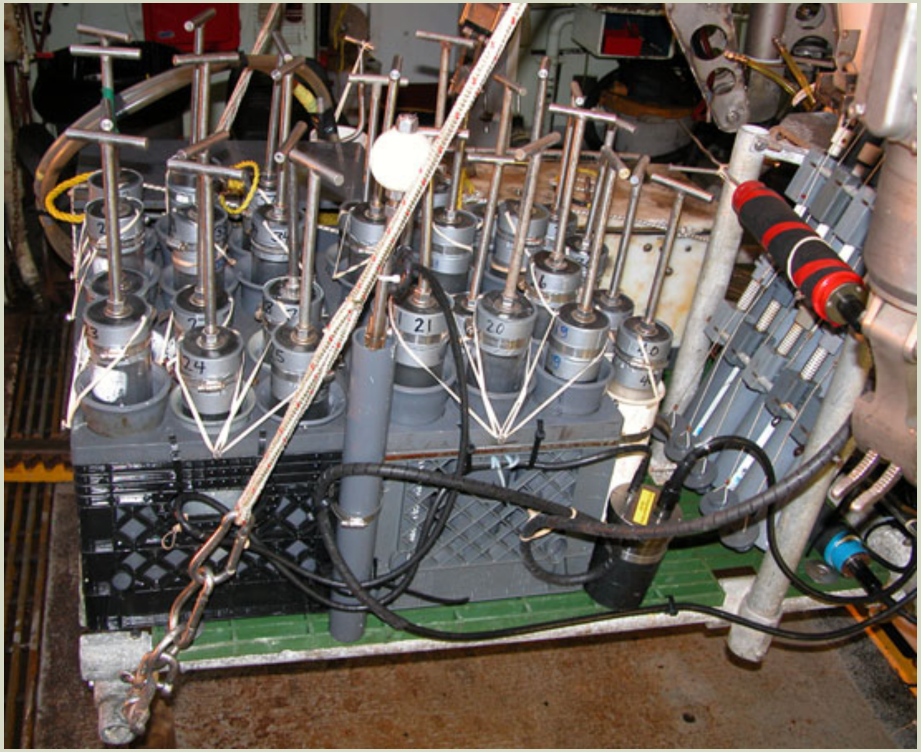
Mounted in a variety of positions



COLLECTION: SEDIMENTS

Push Cores

2.5" id, 12" length



MEASUREMENT: TEMPERATURE

- High Temperature Probe (RTD, thermocouples)
- Low Temperature Probe (thermistor)
- Heat Flow Probe
  - 1m version (5 thermistors)
  - 0.6m version (4 thermistors)
- ICL on Major Sampler
  - thermocouple

MEASUREMENT: CHEMISTRY

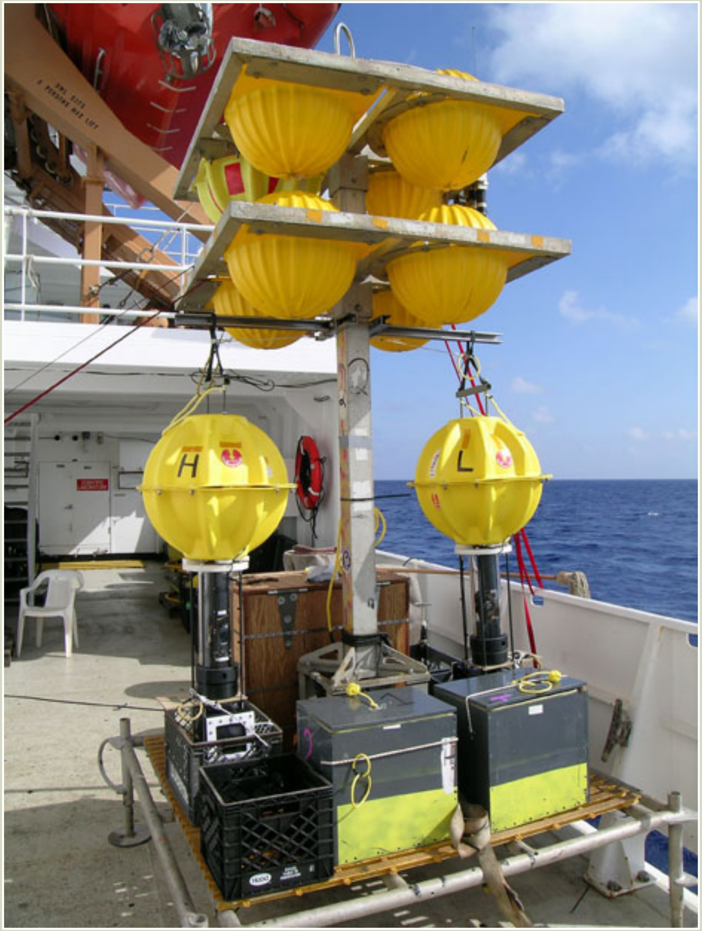
- CTD (conductivity, temperature, depth)
  - Seabird CAT 19
  - Mounted in variety of locations
- Magnetometer
  - Magnetic fields, anomalies
  - Geophysical surveys
- Dissolved Oxygen

EXPANDING COLLECTION CAPABILITIES

Elevators

Facilitate transfer of technology to/from seafloor

Expand sampling capabilities of vehicles (can offload samplers)



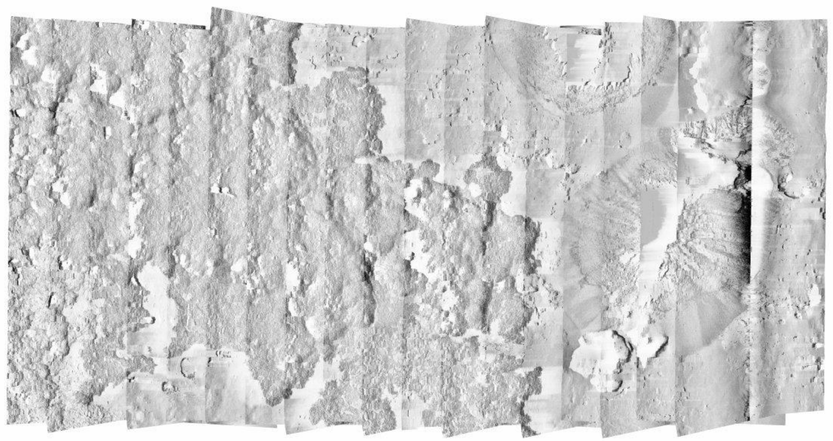
MAPPING AND SONAR

Elevators

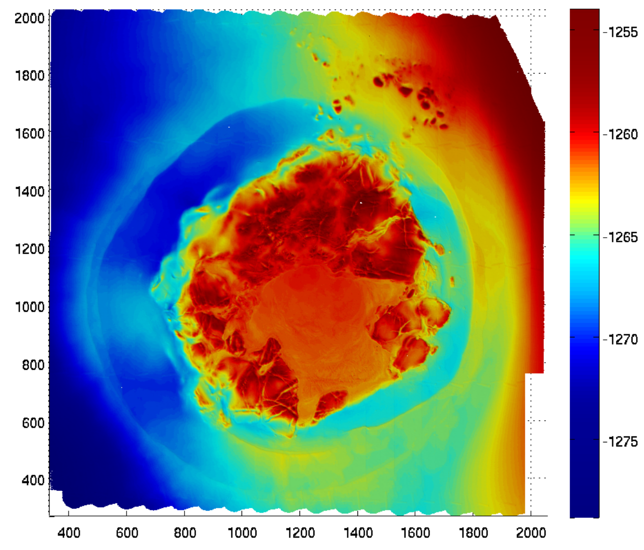
Micro-bathymetry

Backscatter Imaging

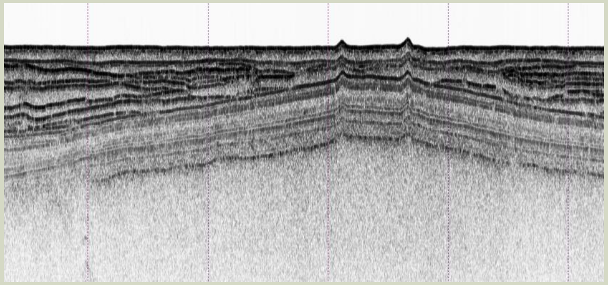
Sub-bottom profiles



Data Collected during a cruised directed by Brian Glazier

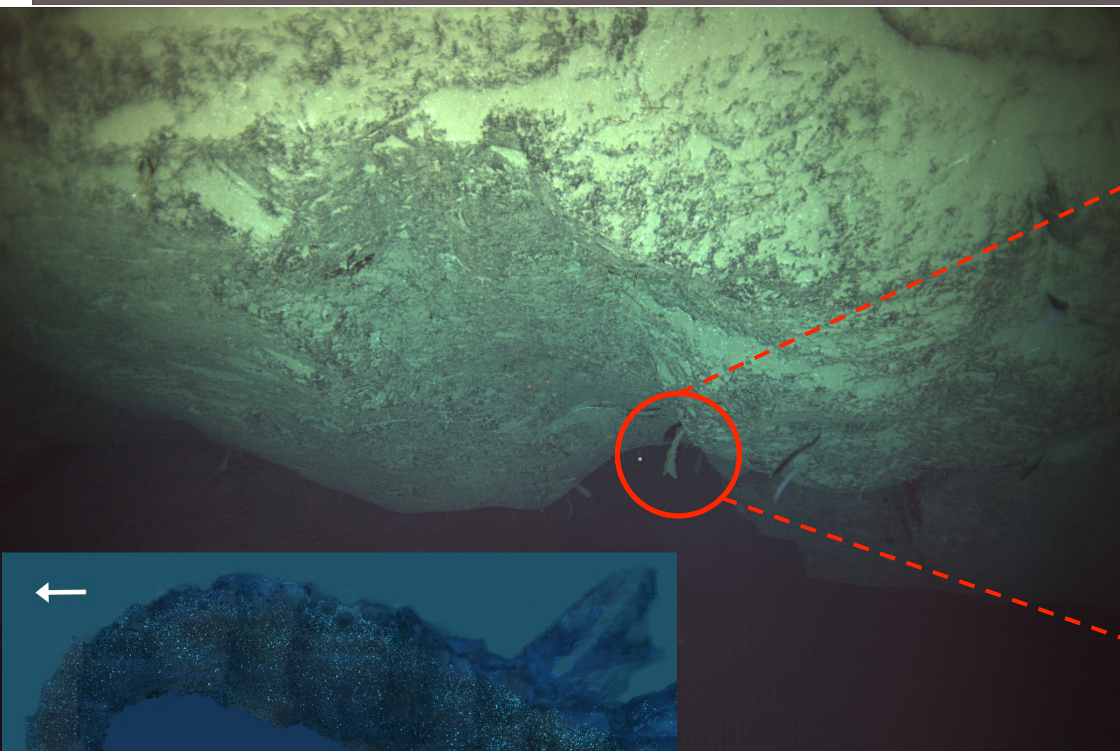


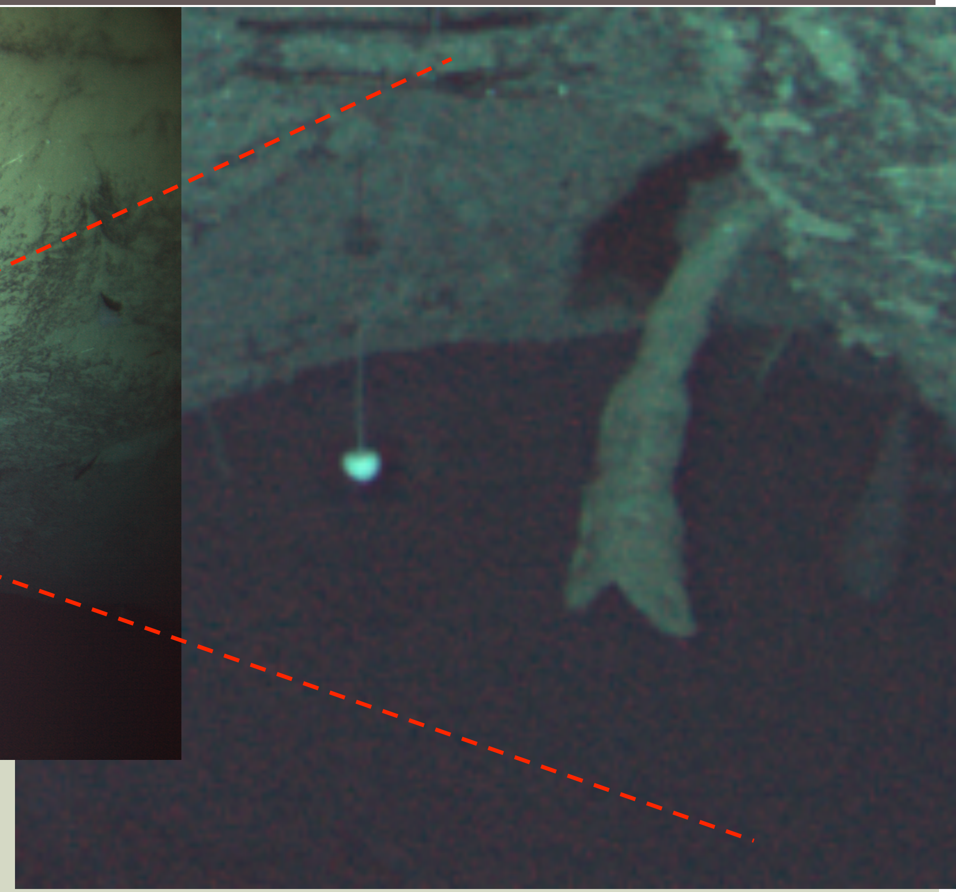
Data collected during a cruise directed by Christopher German

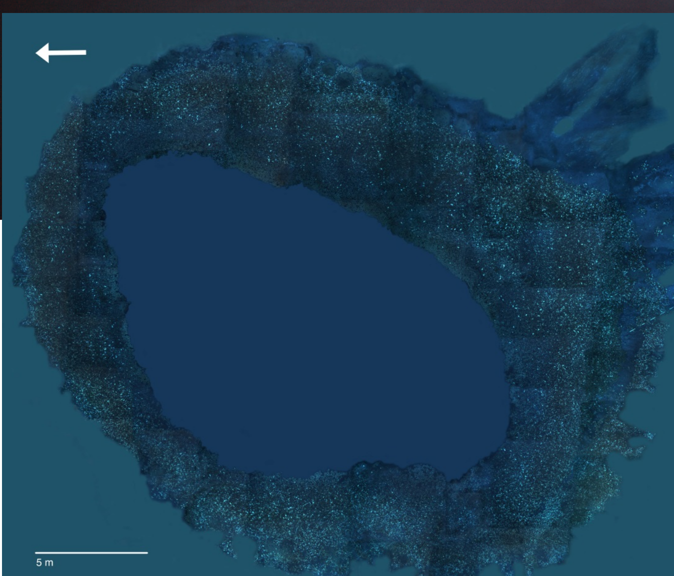


Data collected during a cruise directed by Chris German

IMAGING







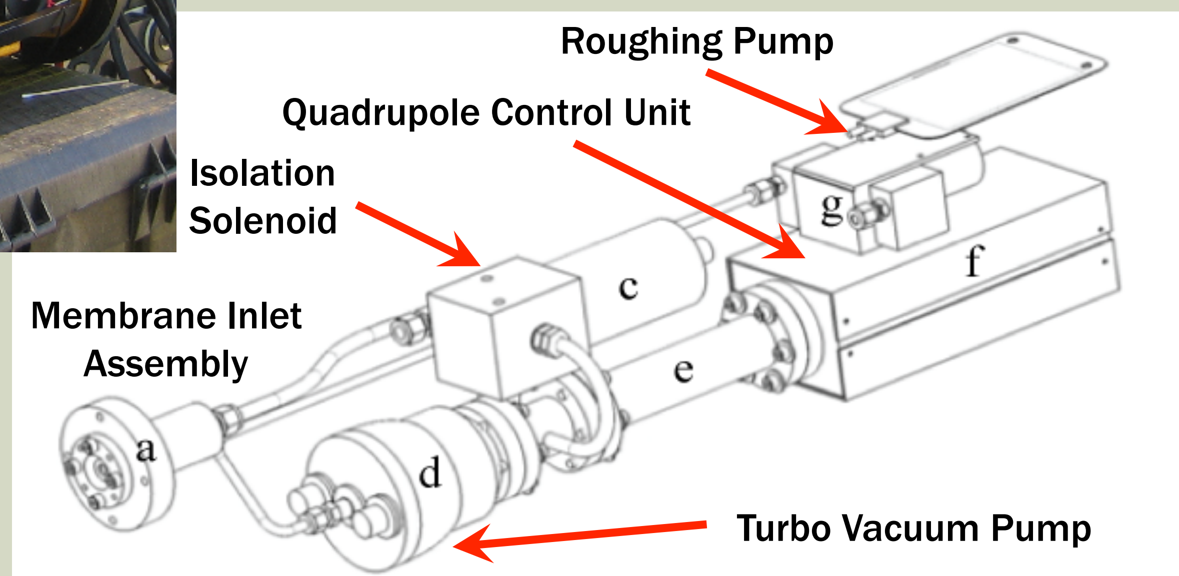
Photos collected during a cruise directed by Cindy VanDover. Mosaics By Eli Cole, Duke University

EMERGING TECHNOLOGIES

DESSC EARLY CAREER WORKSHOP
DECEMBER 7TH, 2013

ANALYZING: MASS SPECTROMETRY

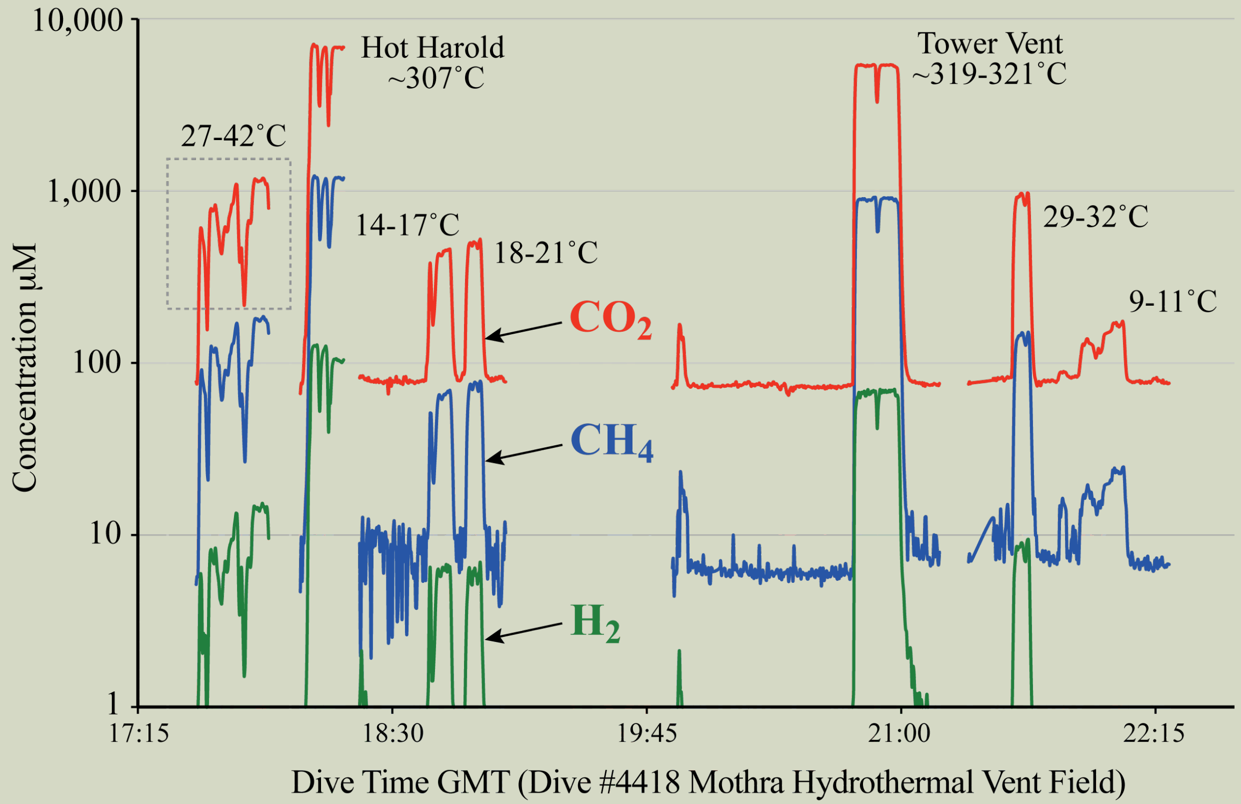
- Real-time dissolved gas concentrations
- Quadrupole Mass Spectrometer with Membrane Inlet
- Ultra-high vacuum, ionization of gases, Faraday Cup or Electron multiplier detection



Girguis lab, Harvard;
Camilli lab, WHOI
Short lab, USF

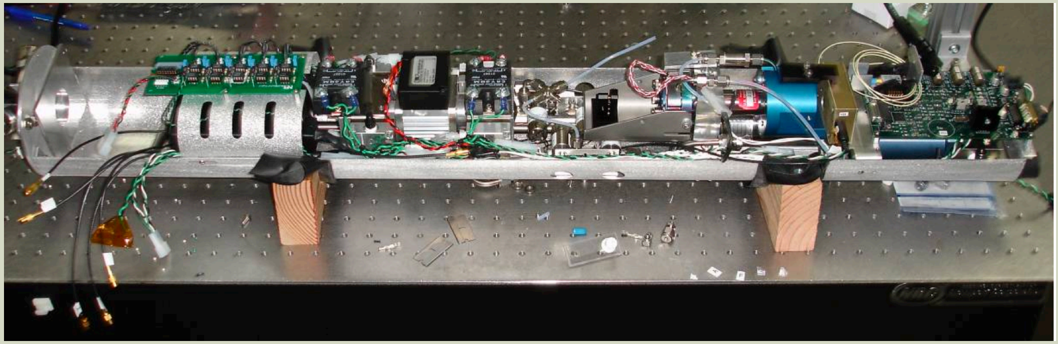
ANALYZING: MASS SPECTROMETRY

- Co-registered analysis of many gas species simultaneously
- Detect/quantify biological and geochemical processes



ANALYZING: LASER SPECTROSCOPY

- In situ stable isotopic composition of gases (CH_4, CO_2, etc.)
- Membrane inlet

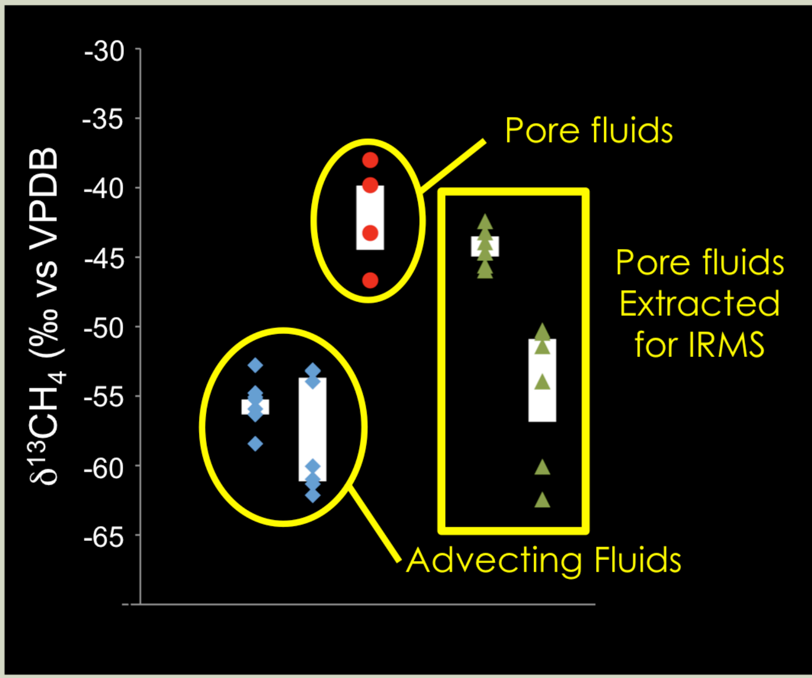


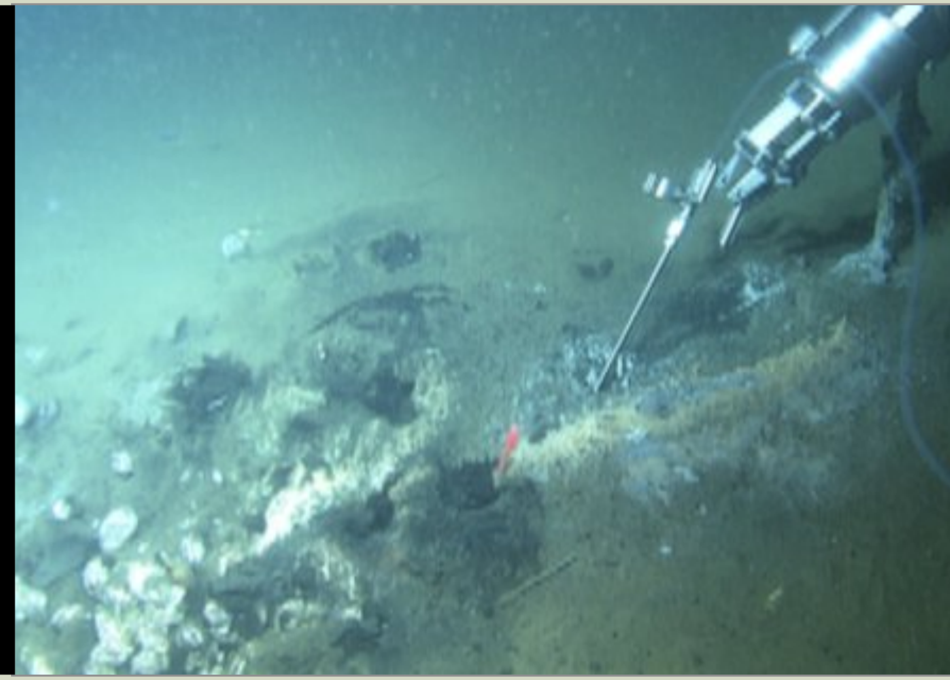
- Integrated Cavity Output Spectroscopy (ICOS)
  - very long pathlength, allows spectral features of $^{12}CH_4$ and $^{13}CH_4$
- Near IR laser source

Girguis lab, Harvard; Wankel lab, WHOI

ANALYZING: LASER SPECTROSCOPY

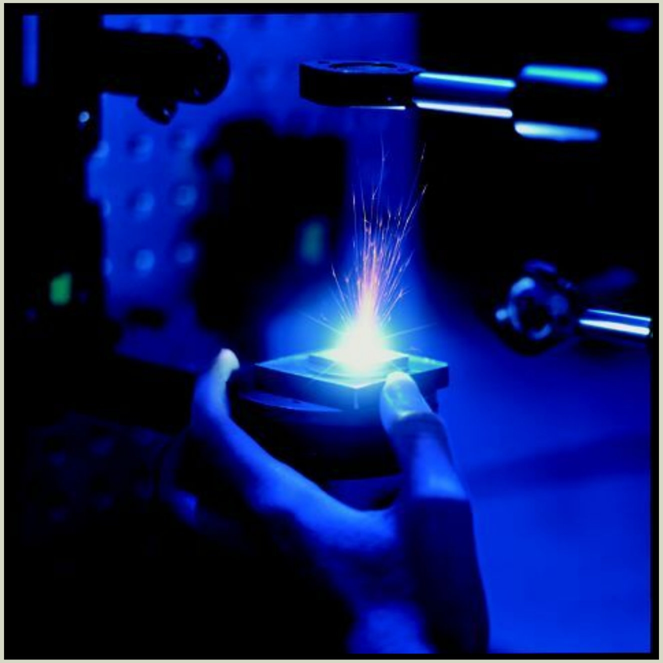
- Isotopic mapping of methane biogeochemistry





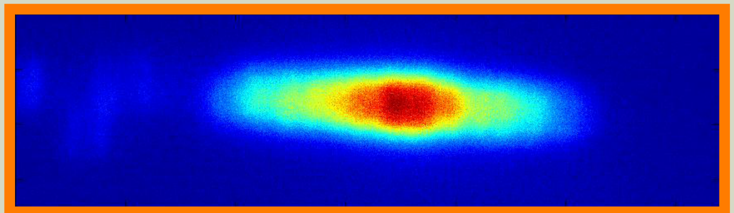
ANALYZING: IN SITU RAMAN (LIBS)

- Laser Induced Breakdown Spectroscopy (LIBS)
- Focus a high powered pulsed laser onto a sample
  - High temperature plasma formation
  - Plasma temperature: 7,000 - 12,000 K
- The plasma:
  - Emits a continuum of radiation
  - Expands and cools
- Excited ions and atoms revert to lower energy states
  - Emit characteristic atomic emission lines of elements
  - Information about chemistry of the sample

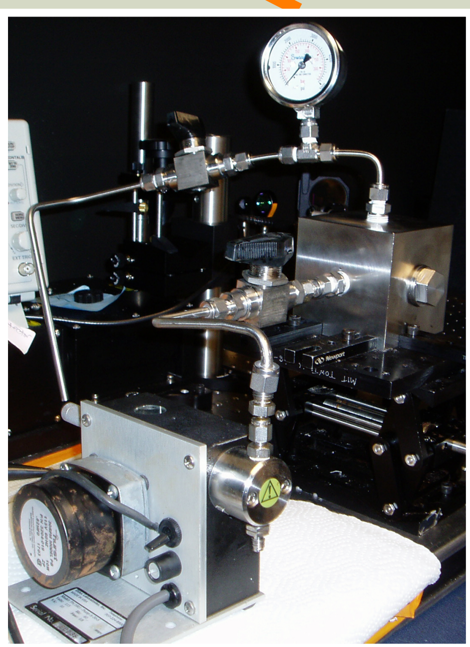


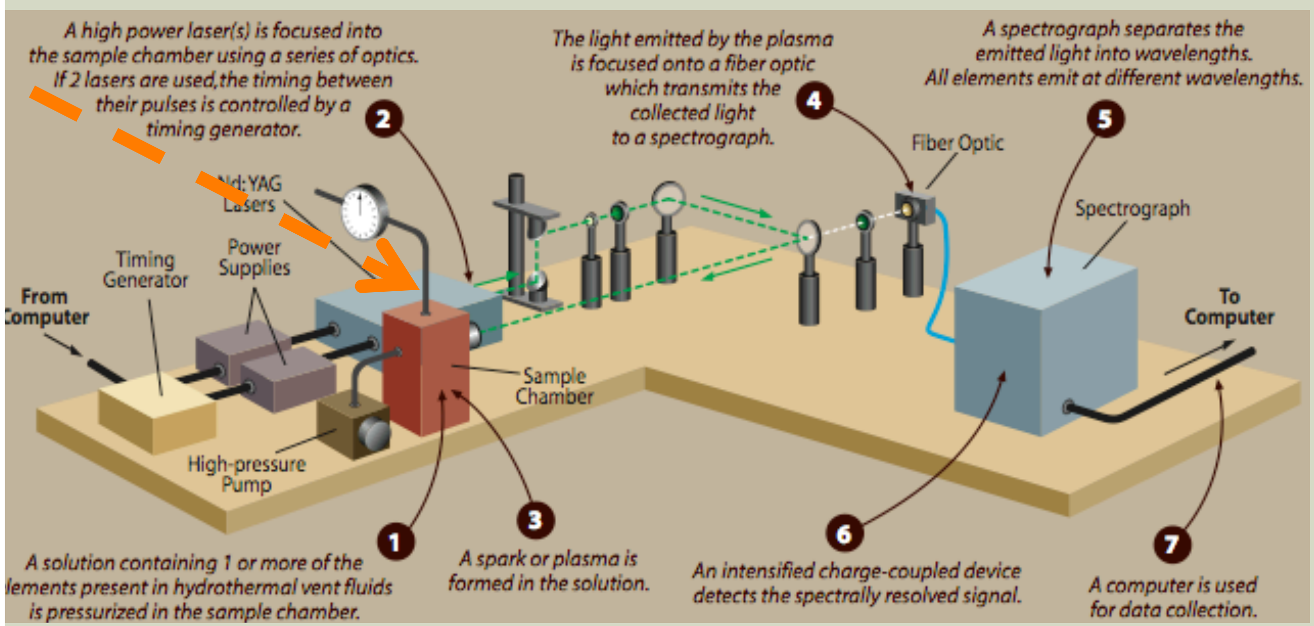
Anna Michel, Alan Chave

ANALYZING: IN SITU RAMAN (LIBS)



Maximum Pressure 4.1 x 10^7 Pa
Simulated Ocean Depth ~ 4000 m

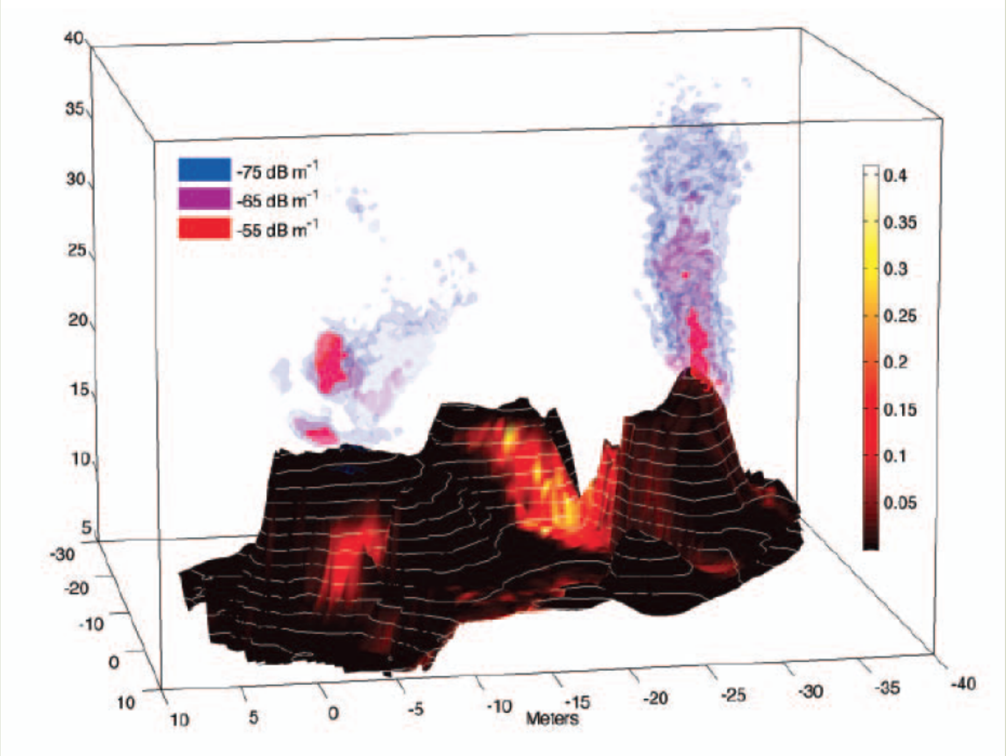




Anna Michel, Alan Chave

MEASURING/IMAGING: COVIS

- Cabled Observatory Vent Imaging Sonar
- Acoustic technique to image active venting
- Doppler processing → estimate of flow rates

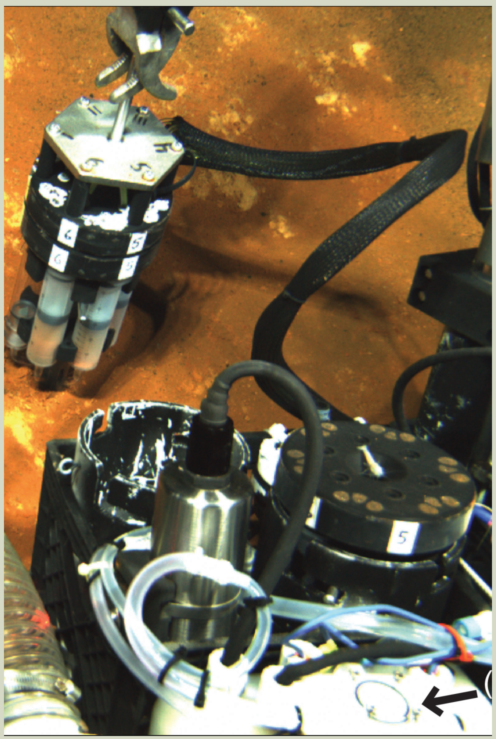


- Reson Multibeam Sonar
- 200/400 kHz projectors
- Adaptable positioning
- Range: 10s meters

Peter Rona, Russ Light

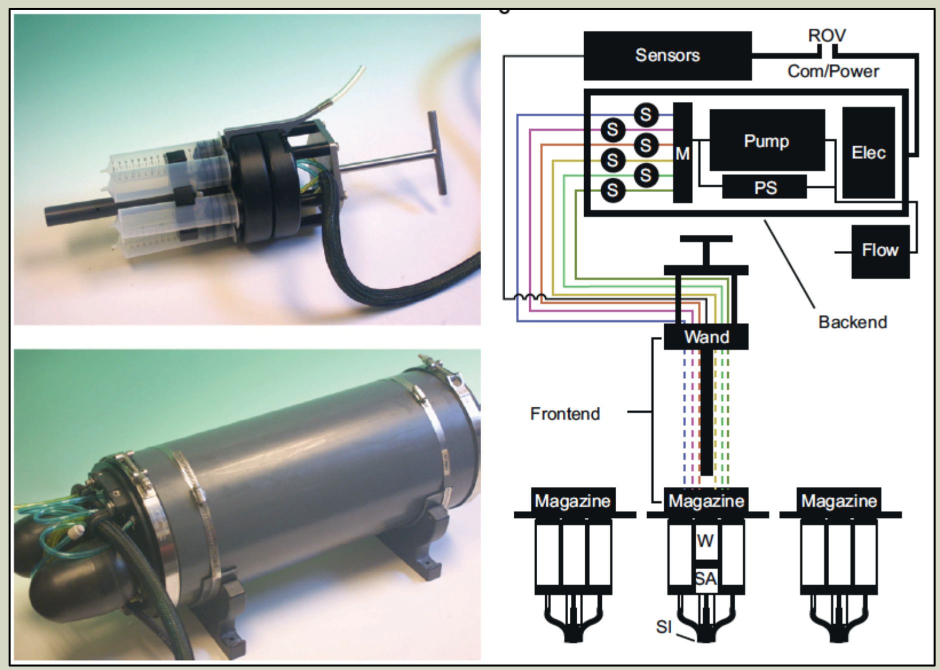
SAMPLING: MICROBIAL MAT COLLECTION

- **Biogeochemical sampling** tools for water column and microbial mat studies



Jason & Mat Sampler

- Magazine of large bore syringes for collecting samples of delicate microbial mats



J. Chip Breier

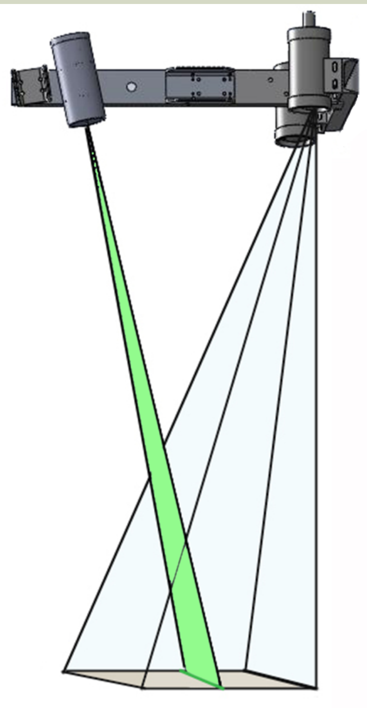
SAMPLING: FILTRATION/PRESERVATION

- **Biogeochemical sampling** tools for water column filtration and preservation of suspended particulate materials

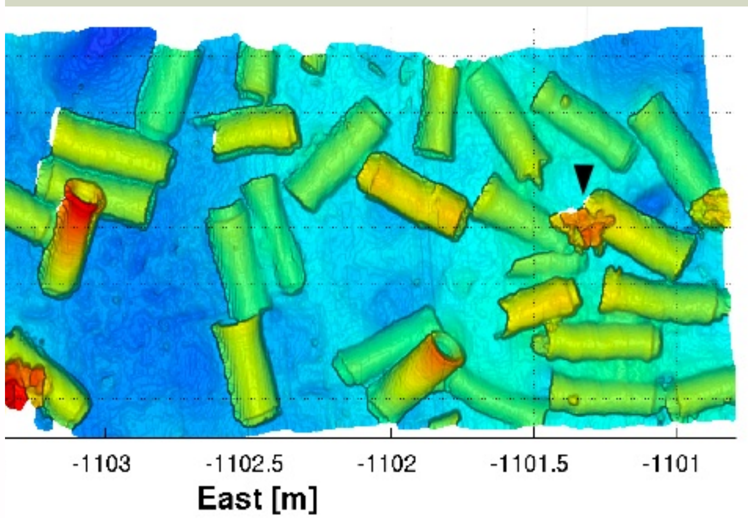
- Sample water is pumped through filters
- Filters are preserved for biological and geochemical analyses
- System adapted for different vehicles

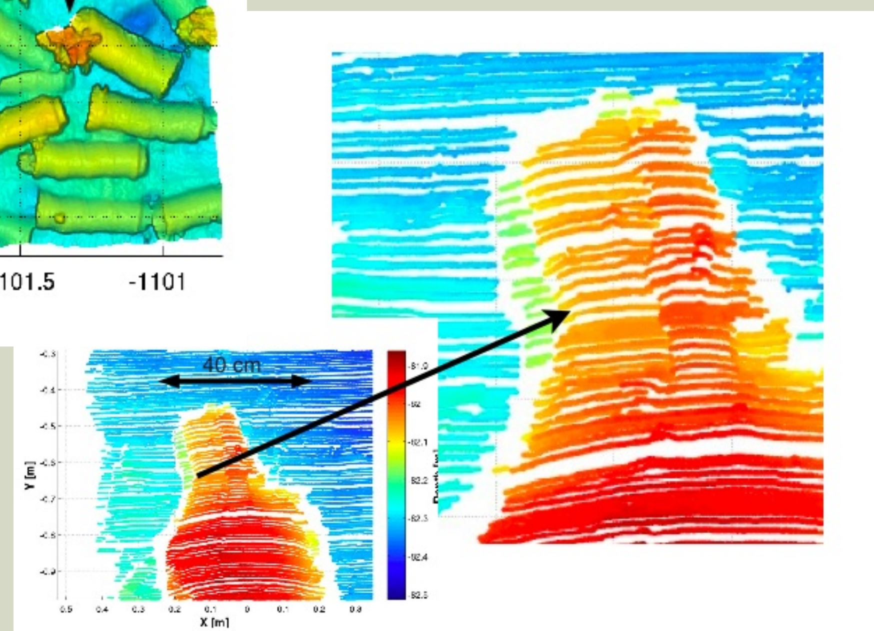
J. Chip Breier

IMAGING: STRUCTURED LIGHT SENSOR



- Verged sheet laser is imaged on the seafloor. The resulting bottom profiles are analogous to single ping of multibeam data.



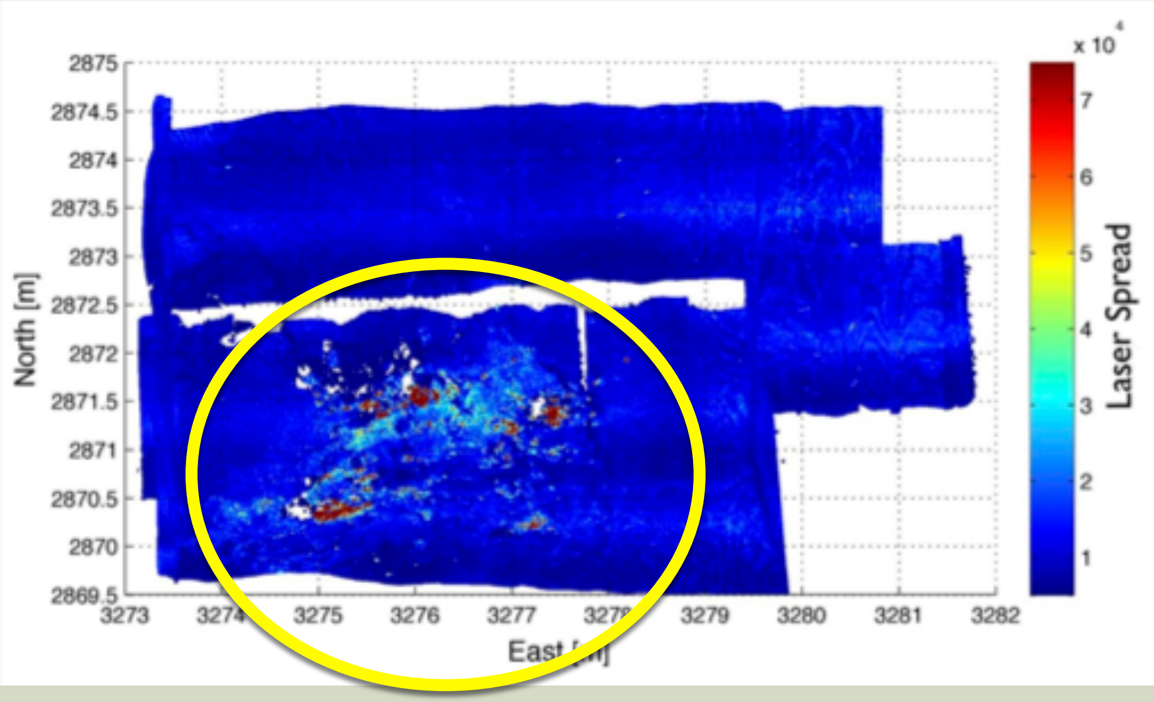


- Operating conditions: 3m altitude, 20 frames/second, vehicle speed 15-22cm/s

Clara Smart, Chris Roman

IMAGING: STRUCTURED LIGHT SENSOR

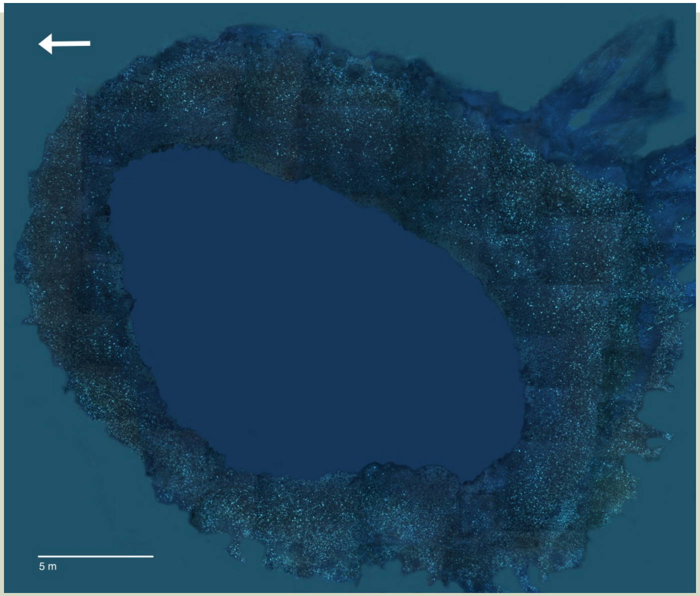
- Laser line is diffracted blurred when passing over diffuse venting (Mirage effect seen in video).
- Use as proxy for detecting diffuse venting!
- Create maps of diffuse venting
- Quantify fluid fluxes?



Clara Smart, Chris Roman

IMAGING: MOSAICS AND 3-D MODELS

- Mosaics via hand (Eli Cole –Duke University pictured) or developmental NDSF pipeline based on MAURUM work
- 3-D re-constructions by Australian Center for Field Robotics



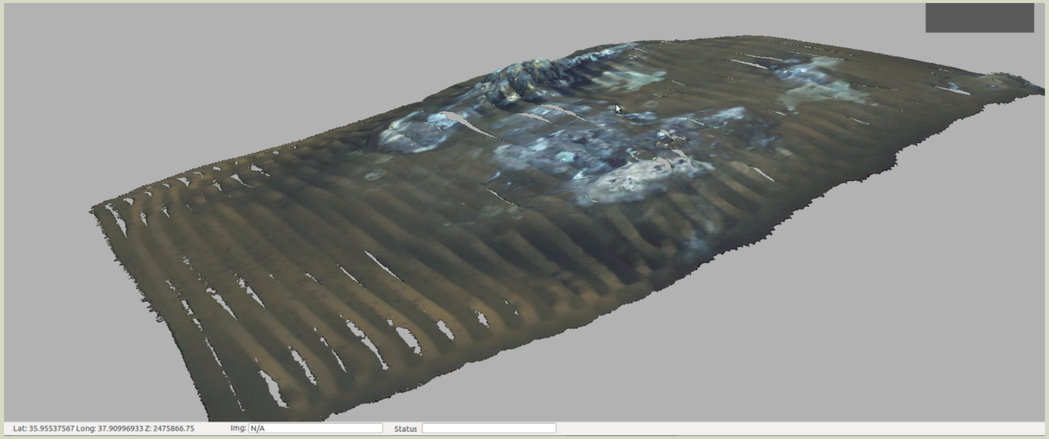


Image Courtesy Dave Valentine and Oscar Pizarro

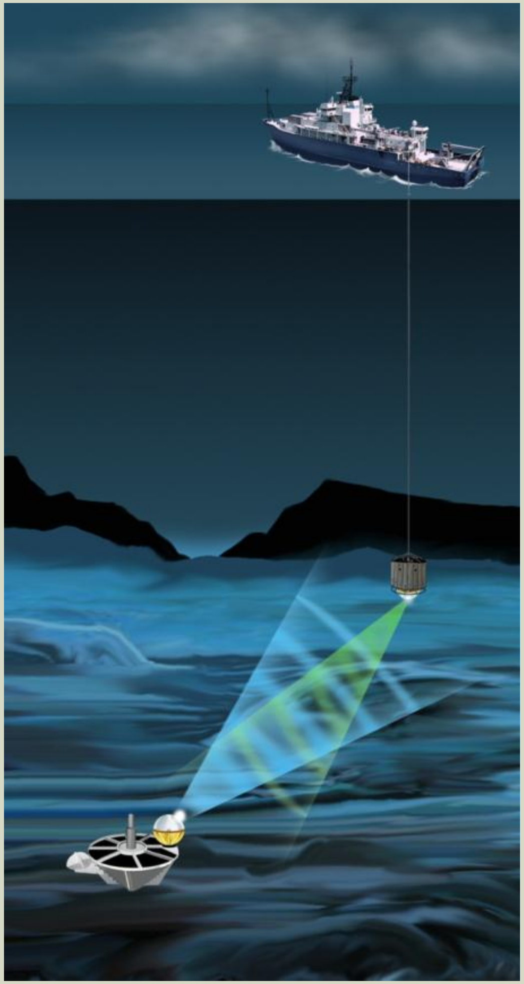
COMMUNICATING: OPTICAL MODEM

- Long range, deep water system
- Scalable transmitters
- 10Mbps rate, 150m range
- 300Kbits/Joule

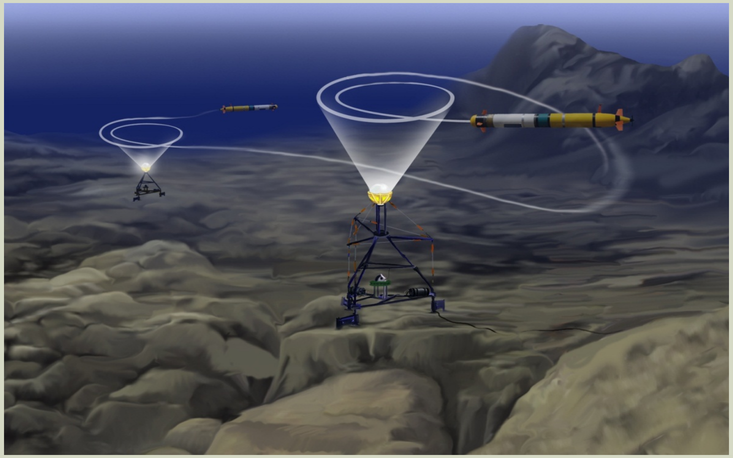
- Silicon based transceiver for full daylight operation
- 5Mbps rate, 10-20 m range

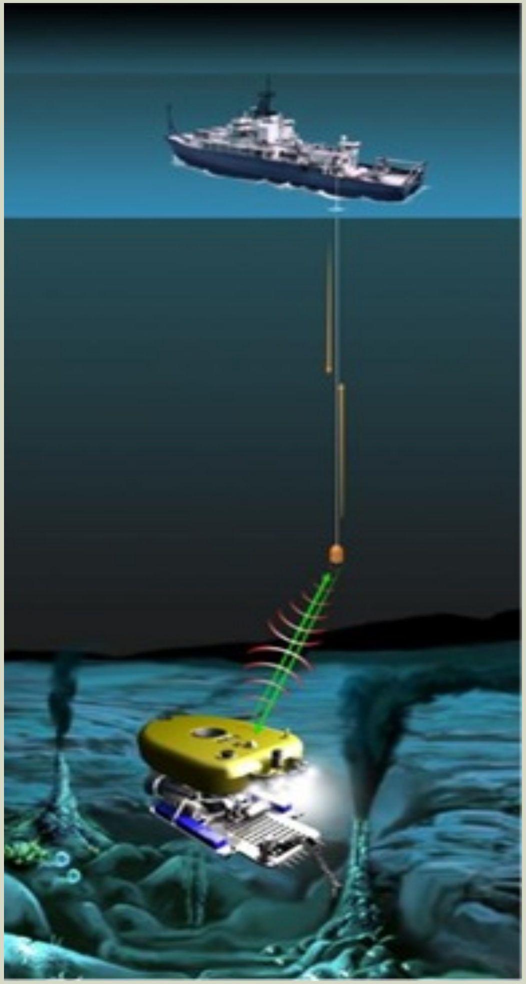
- Commercially available through Lumasys Inc.

COMMUNICATING: OPTICAL MODEM



- Wireless data transfer from seafloor instrument to vessel
- Untethered control of ROV
- AUV based 'Data Mule'





SONAR MAPPING

- Micro Mapping vertical features
- Water Column Imaging

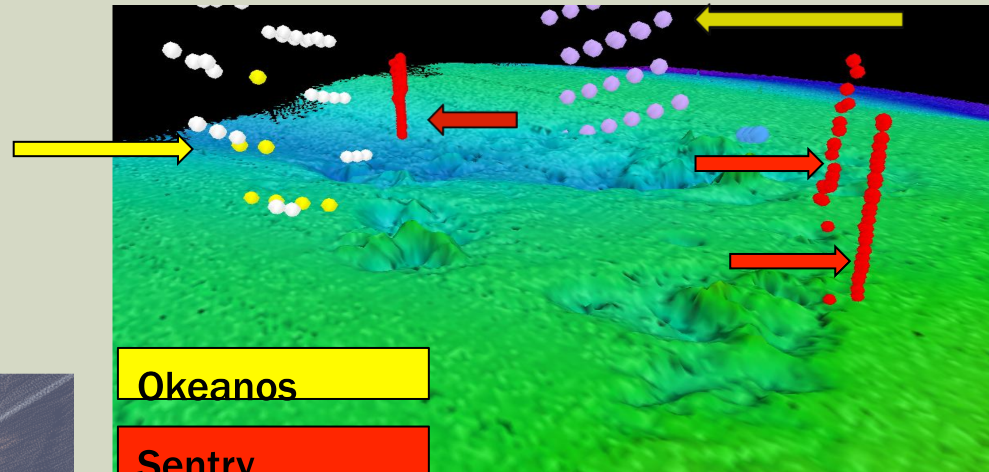
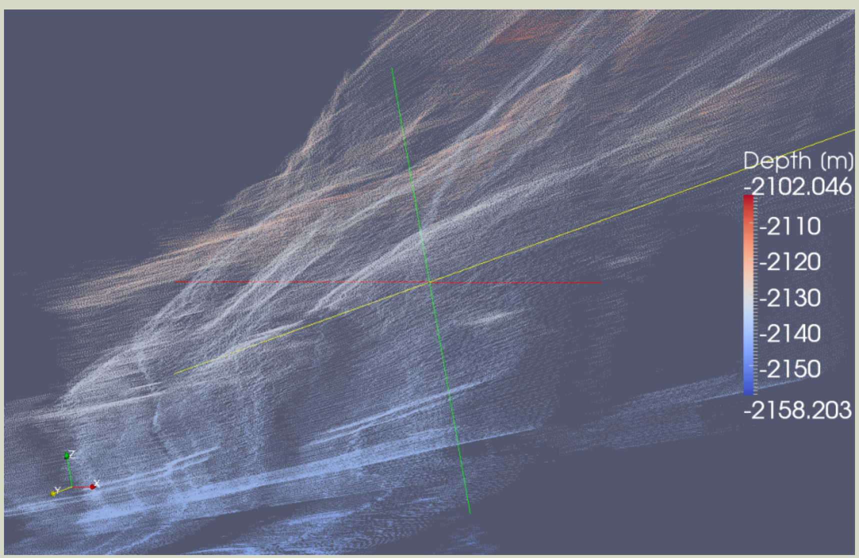


Image Courtesy Cindy Van Dover & Meme Loebecker – NOAA OER



Extreme High Resolution Map of Section of Florida Escarpment with Blueview Sonar – Data collected during a cruise directed by Cindy Van Dover

DEVELOPING AND INCORPORATING TECHNOLOGY

(THINGS TO KEEP IN MIND)

- Questions to ask yourself:
  - What’s the easiest the way to collect the information I need to answer the question?
- KEEP IT SIMPLE STUPID (KISS)
- Ask the experts early and often – They are paid to help you!

LIMITATIONS OF POWER AND SIZE

- Electrical supply
  - Will you need electricity? How much? For how long? Can you get by using less? Could I use hydraulics instead?
  - Can you run off of batteries or will you need power from vehicle?
  - Will your power requirements impact the deployment duration?
  - Will your power demand limit deployment of other tools?
- Basket space, payload availability
  - Will my instrument size impact other aspects of the dive (space for other instruments, handling of the vehicle)
  - Does my instrument need to be handled during the dive? Can it ride underneath, in the back, or out of the way?
  - How much does it weigh in water (all vehicles have weight constraints)

COMMUNICATIONS

- Communications
  - Will I need to ‘talk’ to the instrument to use it?
  - Will the data be collected/logged automatically?
  - Will I need to run a program or turn something off/on
  - What kinds of controls will I need (minimize as much as possible)?
- Pathways of Communication
  - Visual (switches, lights)
  - Serial (RS-232) – low bandwidth – “easy”
  - Ethernet (CAT-5 cables, etc.)
  - Inductively Coupled Link (ICL)
  - Optical Modem

OPERATION AND CONTROL

- Control
  - How easily will it be used by the manipulators?
    - T-handles and monkey fists
  - Do I need to be able to turn things off/on?
    - Can I throw switches from the control van?
    - Will I need the manipulators to turn knobs/switches/valves?
    - Dexterity can be a limitation
  - Do I need to be able to see my data in real time – or can data be logged for review later?
  - How will I know where my data was collected.
    - Vehicle navigation is usually indexed to time
    - Often having the vehicle itself log your data can be the safest easiest course of action – especially for an AUV – requires early collaboration with the operations groups

SERVICIBILITY

- Maintenance/Servicing
  - How easy/hard is it to keep a full set of spare parts?
  - How easy/hard is it to repair, service, rebuild components at sea?
  - Can other people be easily trained to operate, troubleshoot and fix?

OTHER THOUGHTS:

- Linking your data with other dive data (lat/long, time, depth, temperature, photos, video etc.)
- Think about the best way of leveraging your technology with other tools/approaches/researchers
- Give yourself enough time for testing and coordination with engineers, pilots, crew, etc.
- Be thorough, be organized, ask questions, plan ahead

WEB RESOURCES

- DSV ALVIN
  - www.whoi.edu/main/hov-alvin
- JASON
  - www.whoi.edu/ndsfVehicles/Jason
- SENTRY
  - www.whoi.edu/main/sentry
  - Scientist's Guide to working with Sentry (PDF)
- Neptune Canada?
- OOI?
- Other resources?