UNOLS Deep Submergence Science Committee (DeSSC)
Annual Showcase Meeting
Sunday, December 10, 2017

Hilton New Orleans Riverside - Quarterdeck Ballroom AB
2 Poydras St., New Orleans, LA

Meeting Presentations:

- I: Participant List
- II: NDSF/DeSSC Highlights and Accomplishments
- III: UNOLS Global SMR Announcement
- IV: New-Users and Early Career Scientist Presentations - Session I
- V: National Deep Submergence Facility (NDSF) Announcements
- VI: NDSF 2017 Vehicle Operations Summary
- VII: Deep Submergence Scheduling: 2018 Operations and beyond
- VIII: PI Reports:
  - VIIIa: PI Report - Andreas Teske
  - VIIIb: PI Report - Michael Cheadle
  - VIIIc: PI Report - George Luther
  - VIIId: PI Report - Erik Cordes
  - VIIIe: PI Report - Julie Huber
  - VIIIf: PI Report - Pete Girguis
  - VIIIg: PI Report - Amy Baco-Taylor
- IX: NDSF Vehicle Debrief Interviews & Post Cruise Assessment Reports
- X: Summary of Upgrades to NDSF vehicles: *Sentry, Jason*, and *Alvin*
- XI: New-Users and Early Career Scientist Presentations - Session II
- XII: DESCEND-2 Report – Peter Girguis
- XIII: Deep Submergence Science - Community Discussion Session: Goals, etc.
- XIV: *DESCEND to Action* – Breakout Summaries
- XV: DeSSC's New-User Program - Summary of the activities, discussions, and highlights.
- XVI: Video Standards and Data Management
- XVII: DeSSC Subcommittee on Telepresence-Enabled Science Missions
- XVIII: NASA Ocean Worlds Meeting
- XIX: NDSF Data and Telecommunications Study
- XX: OET Mobile System
- XXI: InterRidge
- XXII: Scripps Institution of Oceanography ROV
- XXIII: Schmidt Ocean Institute ROV

Community Discussion Notes:

A major activity of the meeting was a community session to identify new directions for future interdisciplinary programs in deep-sea research. Below is the tasking to the meeting participants along with summaries of each breakout session.

DESCEND 2 ACTION

- **Goal:** To build on the DESCEND2 report with timely actionable and new directions for future interdisciplinary programs in deep-sea research.

- **Anticipated Outcomes:** Stimulate and enable interdisciplinary collaborations and networks, gain insights into challenging problems in deep-sea research that we can rally around, identify steps (e.g., a series of workshops, a Research Coordination Network) for our community, identify heroes willing and able to advocate for new opportunities.

The Grand Challenge

- You have **unlimited resource**s; build an interdisciplinary team to address and **implemen**t an ambitious outstanding question *(or problem)* in deep-sea science (i.e. don't be constrained by current capabilities!, think convergence).
- Each breakout group, about 10 people
    - 1 designated Chair… moves the discussion on, and keeps on track
    - Co-chair (a new user) to assist chair
    - Assign a rapporteur in your group. Rapporteur takes notes, and reports back in plenary

Example type questions:

- What are the geological, geophysical and biological connectivity, extent and dynamics of globally distributed seamounts?
- Questions about the poorly accessed polar regions, the biological and geological connectivity between arc volcanos and backarc basins etc. etc.?
- What are the expressions of deeper earth volatile (esp. Carbon) exchange with the oceans and atmosphere that can be quantified with deep submergence?
- Hadal environments?
- Can we develop an integrated dynamic model of the chemical, biological and geological interactions along deep ocean seamounts?

All groups to answer these 4 bullets

- What are the significance and societal impacts of this goal?
- What is needed to accomplish (**implement**-timely and measurable) the ambitious goals?
    - Consider existing technologies that could be expanded
    - Consider new technologies that will need to be developed
    - Maybe consider types of submergence data that will be needed

- What new interdisciplinary/cross-disciplinary opportunities could potentially emerge?
- What potential challenges could be encountered?

Breakout Sessions:

- Polar ocean environments in a changing world
    - Moderator -Chris German
    - Cochair: Catherine Walker
- Out new and evolving understanding of seamounts and seamount processes
    - Moderator – Amy Baco-Taylor
    - Co-chair Kirsten Meyer
- Interdisciplinary understanding of fracture zone environments
    - Moderator – Nick Hayman
    - Co-chair –Justin Estep
- Advancing understanding of global fluxes of gases from the seafloor
    - Moderator – George Luther
    - Co-chair Adam Skarke
- The temporal and spatial scales of the processes that link the seafloor, water column and atmosphere
    - Trish Gregg
    - Co-chair Oliver Ashford

Breakout Session Summaries:

Polar

- Science questions
    - Baseline for fishing, biodiversity, polar organisms – do this before fishing moratorium and ongoing
    - What are the changing dynamics of fluids and gases on the continental slopes including permafrost and gas hydrate
    - How is the ice changing and how will it change in the future - how does this contribute to sea level rise
    - How do ecosystems evolve following ice shelf collapse, how does this tie into ecosystem services
    - What is the seafloor bathymetry below ice and how does this affect currents (/nutrient transport??) and melting
    - How do seafloor fluid events differ in the arctic and under ice – e.g. hydrothermal at the Gakkel Ridge
    - How do we mitigate human impacts and disasters, e.g. how do we deal with an oil spill/shipwreck/etc.
    - What are the ecosystems and ice shelf grounding lines?
- Significance
    - We have essentially no baseline characterization under ice
    - Arctic currents and changes thereto may significantly affect the global carbon cycle
    - Methane hydrate and permafrost melt may contribute greenhouse gases
    - Arctic provides numerous and increasing ecosystem services
    - Arctic may be bellwether for other changes throughout the planet

- What are the new opportunities
    - Ocean worlds funding
    - Leverage private investment oil/gas/commercial shipping
    - Increased international interest in the arctic
- What are the challenges
    - Cold, dark, far away, not one environment
    - Limited prior exploration -> hard to do hypothesis driven research -> need exploration
    - Need to move quickly to get baseline – change is already happening
- What do we need to accomplish our goals
    - Under-ice robotic systems for characterization – persistent systems that span years
    - Deep water AUV/ROVs (5/6 km)
    - Vehicles that can work on seafloor, midwater, and ice bottom
    - Public outreach to raise awareness of arctic change and change impact – need advanced visualization - documentation
    - Could we ground crawl all the way to the back of the Ross (etc.) ice shelf and lay cable, optical nodes, acoustic nodes, AUV docking stations, etc.,
        - Could trickle charge nodes, vehicles etc. over relatively small cable. Expect to loose the <u>occasional</u> vehicle/node
        - Crawl part of day, trickle charge the remainder

<u>Seamounts</u>

Estimates from satellite-derived bathymetry suggest 100,000 seamounts with volumes that are globally significant - a tiny fraction of these have been visited.

There is a huge diversity of seamounts globally in size, morphology, tectonic environment and they span a huge range ocean environments (e.g., depth).

Different morphologies and sizes, coupled with physical oceanography, influence biological productivity and connectivity.

Societal import:

- Military is interested as potential navigation hazards.
- Mining of cobalt crust (and potential impacts)
- Seamounts have impact on fisheries resources.
- Humans are impacting seamounts with unknown consequences.
- Public doesn't even know what a seamount is.
- Mapping the earth at the same scale as Mars.

What is needed to accomplish goals (cataloging):

- Global-scale cataloging of seamounts (e.g., verification of satellite-derived data).

- Multiple-vehicle ops to cover more ground in the same amount of time (e.g., fleets of AUVs)
- Utilize developing glider, AUV technologies to map the maximum number of seamounts for the minimum cost.
- Allocating existing resources to build the global catalog (i.e., coordinated allocation).
- Take advantage of LOS capacity buildup of mapping resources that will be completed before too long.

What is needed to accomplish goals (processes):

- Tools for sampling (e.g., drills) - determine cobalt crust thickness and whether it is a potential resource.
- Define the variability within seamounts (morphology, geochemistry, size, depth, age, corals, fish, etc.) in order to determine which characteristics are important for defining 'different' seamounts.
- Use automated imaging software (machine learning) to automate the process of characterizing seamount.
        - Analog: the bird genome project.
- What is the best way to get a lot of sample? Devices that can stay out for a whole year, can sample temporally (e.g., deep sea flow-cytobot). This needs to be done on multiple seamounts and between, at multiple depths, etc.
- Sampling for geology and macrofauna (need enough sample (time) for pop-gen studies).
- eDNA in order to determine what is there (biologically) that can't be seen.
- Tools for dating in order to determine the geodynamic drivers for producing seamounts.

Interdisciplinary:

- Biology is influenced by the morphology and micro topography of the seamount,
- PO element in seamount studies, how does seamount influence flow that impacts nutrient availability, larval transport.
- Mass and chemical flux from the mantle to hydrosphere (gases)
    - Crustal fluid flow uses seamounts as inlets and outlets

Challenges

- Global distribution and wide spacing between seamounts is a challenge to get assets in place.
- Sampling limitations - getting enough sample, temporal sampling.
- Being actively impacted…finding those that aren't impacted.
- Having enough long-term monitoring to understand temporal changes (over say a decade)?

Where in the world?

- Central Pacific has seamounts with significant cobalt with active leases, fisheries impacts, and strategic military location, and a good mix of size and distances.

“Life cycle of transform faults and fracture zones”

Justin Estep
Tinah Martin
Nick Hayman
Sean Kelley
Mike Perfit
Jeremy Deans
Andy Bowen
Jeff Carson
Cindy Van Dover
Thomas Morrow
Fernando Martinez
Collin Brandl

Significance

- Fracture zones are a global-scale physical feature found in almost every ocean basin, recording tectonic history from modern-day ridge processes through subduction. Despite this, they are relatively studied from a geologic, biologic, and oceanographic perspective.
- Due to their scale, they reveal the history of crustal accretion and provide a “road cut” into the oceanic crust and its evolution from ridge to subduction.
- Magmatism in transforms and fracture zones is relatively uncontaminated by ridge processes and provides a window into mantle processes from a different perspective than ridge or seamount lavas. Fracture zones are some of the largest physical contrasts in the seafloor surface and have pronounced effects on ocean currents.
- The depth and separation of fracture zones may produce isolated biogeographic provinces
- Due to their depth, fracture zones may provide an unconventional sediment trap, possibly a hydrocarbon source? The extent of this is relatively unexplored
- Fracture zones provide a constraint for plate motion models
- When subducted, fracture zones represent one of the largest regions of variability in volatile content and sediment load being transported into the mantle. This may affect the overlying arc volcanism in a way that directly impacts human populations.
- It has been suggested that fracture zones provide a weak seed for subduction initiation, with sufficient convergence.

Observational needs

- To characterize fracture zones we need extensive mapping across large and small scales

    - A mapping campaign would require an AUV that can navigate steep scarp environments
    - Due to the size of fracture zones, the AUV must be able to cover large distances at high resolution, and will probably have to be independent of launch/recovery vehicle for long periods of time
    - Side-looking capabilities will be essential to survey vertical scarps
    - These needs may require a "smart" AUV that can dynamically navigate (i.e., "smarter" than simple collision-avoidance capabilities
- Due to fracture zone size, coregistering large- and small-scale observations is essential
- The aging of fracture zones may mean signals of heat flow or fluid-rock interactions will be difficult to resolve, relative to typical measurements at a mid ocean ridge, for example

Interdisciplinary/cross-disciplinary

- Overcoming mapping challenges (mostly terrain) for fracture zones will provide advantages in planetary exploration, where remote-sensing methods must deal with similar obstacles (vertical scarps, global scale, etc.)
- Observational capabilities (derived to address geomorphologic challenges) will aid biologic explorations in similar locations, which are similarly unexplored

Challenges

- Technology for these explorations probably exists but will need to be synthesized on a capable platform
- To properly characterize fracture zones, we will need a global data set across scales (i.e., we need to characterize a global feature from what will likely be site-scale observations)
    - Global data will take time to assemble and be difficult to manage efficiently

Advancing understanding of global fluxes of gases from the seafloor

CO2, Methane, N2, Helium

Societal impact

- Green house gasses (CH4, CO2)
- Carbon cycling and understanding life on earth
- Processes that can provide enzymes for medicine development
- Natural gas resource?

What is needed?

- Map of all these vents and seeps
- In situ equipment to measure gas fluxes, gas speciation. Mass spec?
    - Seeps and vents aren't always active

- Low powered, rugged, tiny, biodegradable chemical sensors
    - Argo float?
- Remote sensing
    - Mapping from afar than right at the seep

Interdisciplinary

- Linking gas fluxes to seismic events (stability) and biogeochemical processes
- Investigate NSF structure to break down interdisciplinary boundaries
- Collaborate with technical field to make sensors
- Can other people help?
    - Navy

Challenges

- Things we don't know what we need to measure
- Temporal
- Equipment
- Global Scale

Broader Impact

- Educational outreach tools
    - Videos get people excited!

The temporal and spatial scales of the processes that link the seafloor, water column and atmosphere

What are the significance and societal impacts of these goals?

For many of us, the linkage between the deep sea and the rest of our biosphere is self-evident.

That said, the mechanisms and sensitivities are poorly constrained:

- 50% of Earth's oxygen is marine microbial in origin.
- Deep sea buffers thermal and chemical changes in our atmosphere
- Deep sea derived elements feed into upper ocean communities, support commercial fisheries
- Ecosystem services of deep sea habitats that support/harbor commercially relevant species
- 90% of volcanic activity and associated seismic activity takes place in the ocean
- Such projects will enable us to understand the feedbacks (both positive and negative) of anthropogenic activities in the ocean system.

What is needed to accomplish the timely goals?

- A MOVING array of effective DISTRIBUTED, AUTONOMOUS, RESILIENT, ADAPTIVE platforms and sensors to capture the 3D temporal and spatial processes at appropriate scales!
    - E.g. - a “marching array” of seismometers that could be moved across the seafloor and through the world ocean basins.
- More effective subsurface communications!
- DEEP LEARNING computers to facilitate automated data processing and analyses.
    - Processing raw data tens to be the biggest roadblock to using the data.

What new interdisciplinary opportunities could emerge?

- Terrestrial, atmospheric and ocean scientists establishing efforts that characterize the linkages among processes in each of these regions.

- Take the atmospheric models that are FAR better developed and work backwards from those climate models and to work back to identify new areas of inquiry (geographic, scientific) in our ocean.

- THAT’S ALSO where we scientists could be more involved in the advances in autonomous vehicles

- A lot more to learn about the role of animals in matter and energy flux in the ocean system.

What potential challenges could be encountered?

- We NEED to have a good/better dialogue with modelers. The resulting data, mgmt. has to be <u>usable</u>.

- DEEP LEARNING computers to facilitate automated data processing and analyses. This may be a big challenge.

- <u>How exactly</u> do we build a 3D array to capture the VASTNESS of the water column? Expendable?

- <u>Re-envision our funding structures!!</u>