

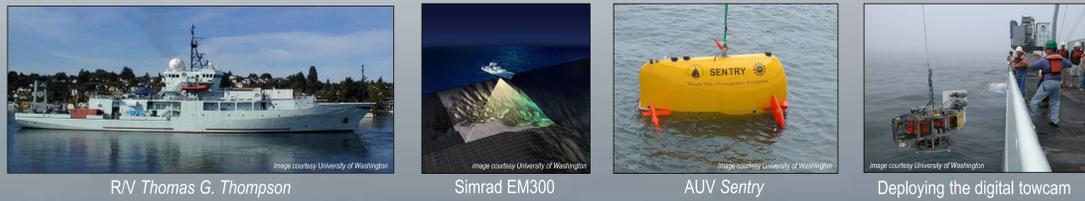
### BACKGROUND

The National Science Foundation's Ocean Observatories Initiative (OOI) is taking marine science to a new level. Using a fiber optic telepresence network, undersea volcanoes, marine biota, and new energy sources are being studied in extreme conditions unfit for humans. The Regional Scale Node (RSN) of the OOI, led by the University of Washington, is currently being created off the coast of Oregon and Washington to study a suite of marine phenomenon on the Juan de Fuca Plate (Figure 1). Two sites on the Juan de Fuca Plate were mapped, Axial Seamount (Figure 2) and Hydrate Ridge (Figure 3). Each site will contain a node, containing an electronics package for routing data and controlling power to individual instruments (Figure 4). Each node (Figures 5-6) is supplied with 10,000 volts of electricity via buried seafloor cable, and will transmit up to 100MB of data per second back to computers ashore.

**Axial Seamount** is an undersea volcano located on the western edge of the Juan de Fuca Plate, along the Juan de Fuca Ridge. This seamount is located at 46°N, 130°W, approximately 300 miles west of Cannon Beach, Oregon. Axial Seamount represents the most magmatically and seismically active site along the Juan de Fuca Ridge. Hydrothermal vents are located on various sites along the seamount's most distinguishable feature, its caldera. As a result, this site was chosen with the intention of gaining greater insight into volcanism and hydrothermal venting processes. **Hydrate Ridge** is an accretionary structure on the Oregon continental shelf, formed by the subduction of the Juan de Fuca Plate beneath the North American Plate at the Cascadia subduction zone. Methane seeps at the Hydrate Ridge site have resulted in the formation of gas-rich hydrate deposits. Methane hydrate, a possible new energy source, is held stable at depth by the hydrostatic pressure of the overlying ocean; however, if the pressure is relieved, the hydrate will turn to gas, causing a massive influx of carbon dioxide and potentially affecting global climate.

### DATA ACQUISITION

Multibeam sonar imagery from Axial Seamount and Hydrate Ridge were collected 22 July – 5 August, 2008 during the InSite08 cruise on the University of Washington's research vessel, the R/V *Thomas G. Thompson*. The research cruise was a joint venture of the University of Washington, Woods Hole Oceanographic Institute, and Arizona State University, and was funded by the National Science Foundation. Multibeam data were collected using a Simrad EM300 multibeam system, and the *Sentry*, an Autonomous Underwater Vehicle (AUV). In addition, a deep-towed digital camera was utilized for ground-truthing. College of Charleston alumni Mike Reed and Andrew Kennedy (both 2008 graduates) participated on the cruise as survey technicians. The College of Charleston acquired the raw data from University of Washington for processing. Using the CARIS HIPS 6.1 software, high resolution, three-dimensional images of Axial Seamount and Hydrate Ridge were produced.



### ABSTRACT

Axial Seamount and Hydrate Ridge are planned sites for the Regional Scale Node (RSN) component of the Ocean Observatories Initiative (OOI), located on the Juan de Fuca plate off the U.S. Pacific Northwest coast. Both sites are hydrothermally active and support diverse biological assemblages. Axial Seamount, an undersea volcano, is the most magmatically and seismically active site on the Juan de Fuca Ridge. Hydrate Ridge is part of the Juan de Fuca subduction zone along the edge of the Oregon continental shelf. Its sediments contain significant amounts of methane hydrate. In July 2008, both areas were mapped extensively using multibeam sonar during the INSITE08 research cruise aboard the University of Washington research vessel R/V *Thomas G. Thompson*. These multibeam datasets were processed using CARIS HIPS 6.1 software. The resulting bathymetric imagery reveals the unique geological setting of these areas.

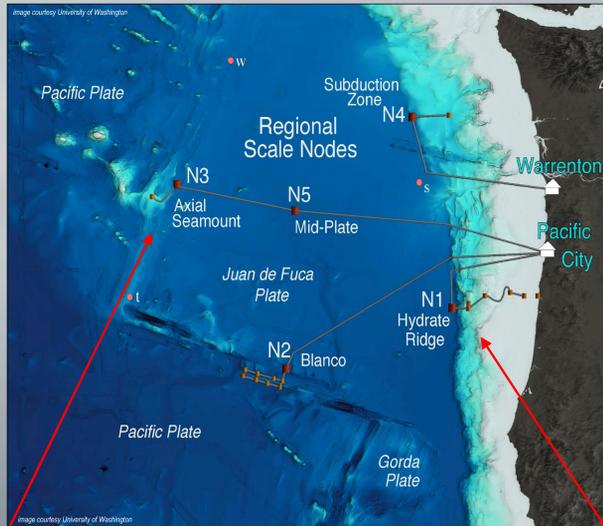


Figure 1. The Regional Scale Node (RSN) system, off the coast of Washington, USA.

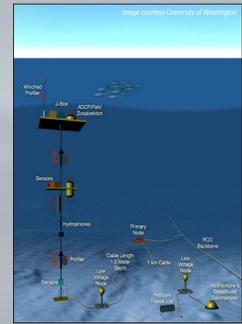


Figure 4. Regional Scale Node system. Each primary node is networked to a variety of scientific instruments, providing the required voltage as well as enabling communication and data transfer between instruments and shore stations.

### DISCUSSION

As the most magmatically and seismically active site along the Juan de Fuca Ridge, **Axial Seamount** represents a fundamental source of knowledge for the ongoing study of volcanic and hydrothermal activity. Major hydrothermal activity areas within Axial Seamount include the ASHES vent field in the southwest portion of its caldera and the CASM vent field in the northern end of the rectangular caldera. The presence of a series of old lava flows along the southwestern portion of the caldera serve as indicators of numerous past eruptions that have occurred in this magmatically heightened area, including the last detected eruption of 1998. Seafloor instruments have recorded evidence for several possible intrusion events within the last decade. The positioning of Axial Seamount, directly in between two rift zones (North and South), is the most likely cause for its frequent volcanic activity. Thus, additional scientific investigation is needed in order to monitor the continual volcanic activity of this site and to comprehend its connection to the hydrothermal and biological systems in the surrounding area.

Since the discovery of cold seeps and associated vent fauna on **Hydrate Ridge** over two decades ago, it has been the focus of many studies which documented significant methane seeps hosting diverse biological assemblages and formation of gas-rich hydrate deposits near the seafloor. In addition, Hydrate Ridge has also been the site of Ocean Drilling Program (ODP) Legs 146 (Site 892) and 204 (Site 1249). Science focused around Hydrate Ridge will be interdisciplinary, integrating the study of carbon transport from the margin to the deep sea with processes that control gas hydrate storage in accretionary margins. In recent years there has been intense interest in these deposits because they represent a potentially huge new energy source; the amount of methane hydrate present in sedimentary reservoirs such as Hydrate Ridge is somewhere between two and ten times all the currently known reserves of conventional natural gas. In addition, methane is also a powerful greenhouse gas; the sudden release of large amounts of methane from methane hydrate deposits has been suggested as a cause of past and possibly future climate changes. Large methane releases have been linked to the Permian-Triassic extinction event, which occurred 251 million years ago and eliminated 96% of marine species and 70% of terrestrial species, and the Paleocene-Eocene Thermal Maximum, the most rapid and significant climate change event of the Cenozoic Era. According to the Intergovernmental Panel on Climate Change (IPCC), methane has a global warming potential of 62 over 20 years and 21 over 100 years.



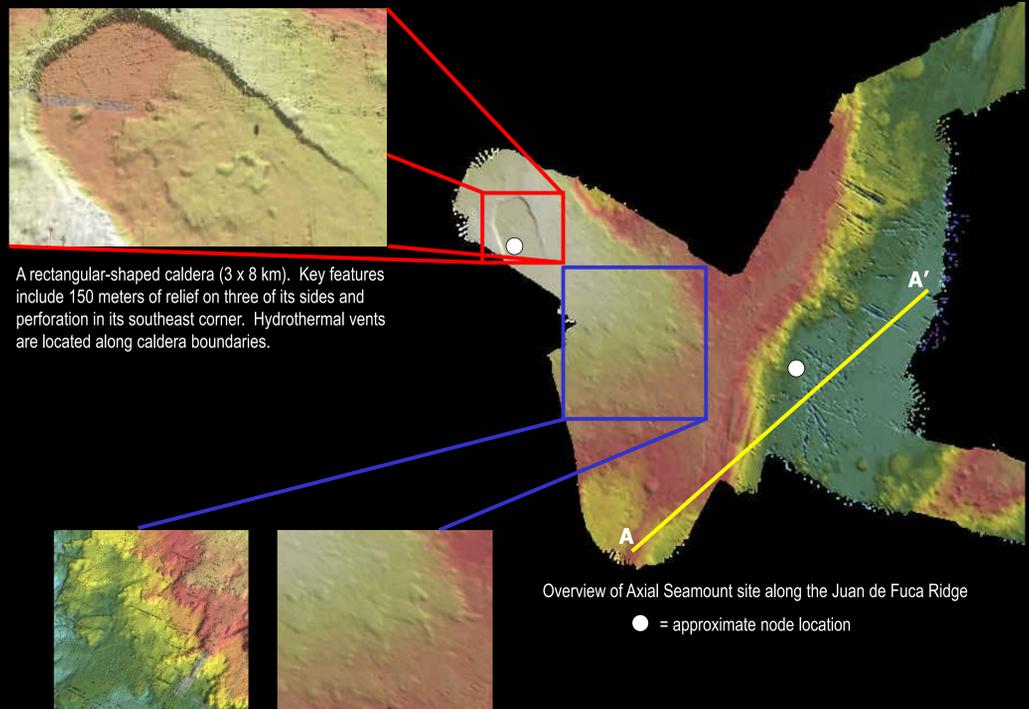
Figure 5. Primary node, pre-deployment.



Figure 6. Primary node, deployed.



**Figure 2. AXIAL SEAMOUNT (NODE 3)**

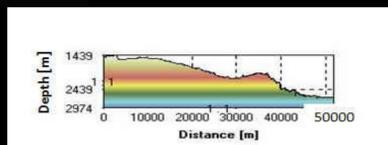


A rectangular-shaped caldera (3 x 8 km). Key features include 150 meters of relief on three of its sides and perforation in its southeast corner. Hydrothermal vents are located along caldera boundaries.

A series of old lava flows in the southwest portion of the caldera, indicative of numerous past eruptions.

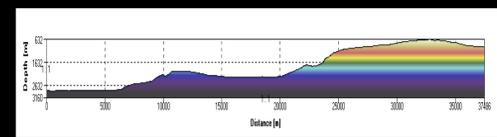
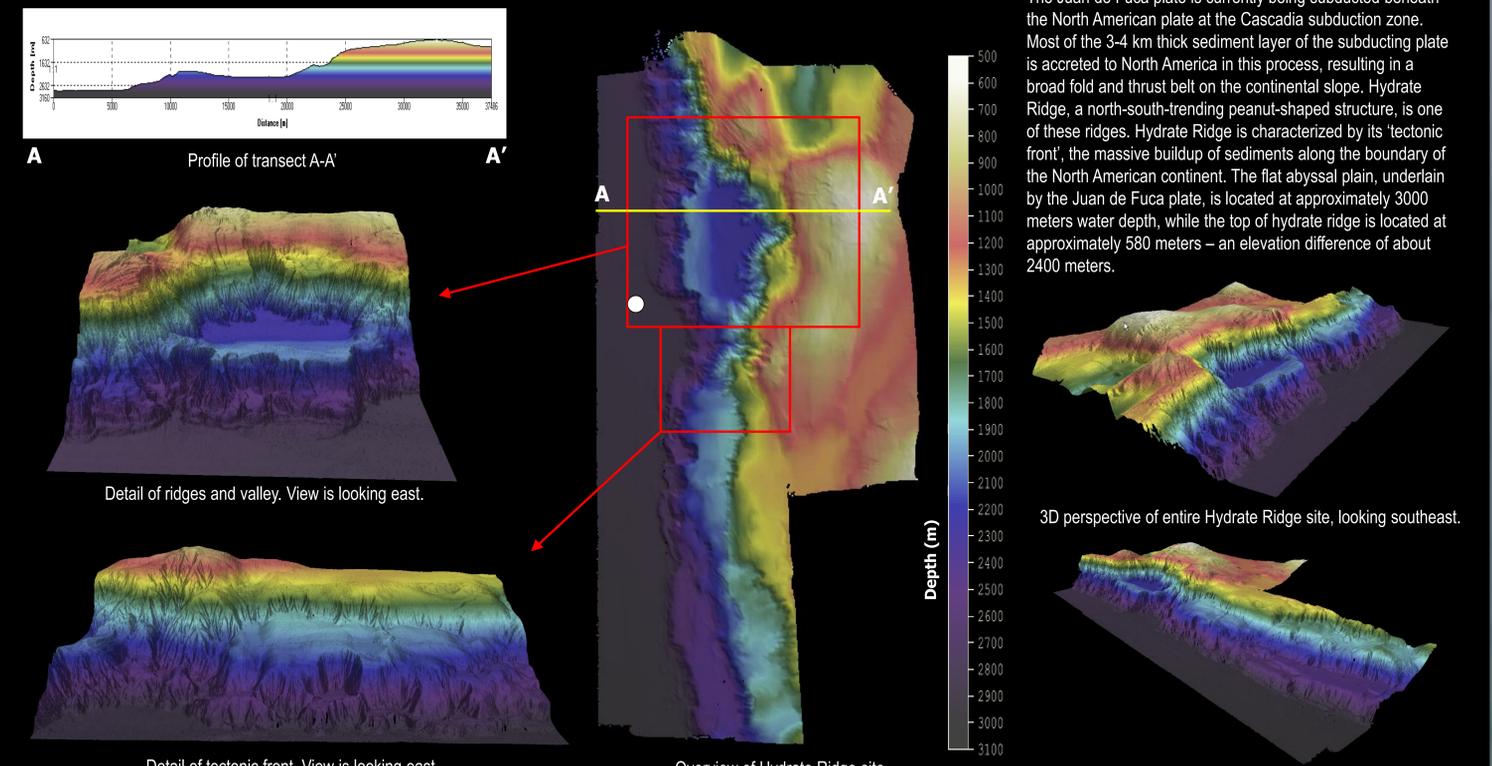
Overview of Axial Seamount site along the Juan de Fuca Ridge  
● = approximate node location

A red box on the overview figure of the Axial Seamount site marks an unusual rectangular-shaped caldera that is located at the summit of the volcano. This caldera, approximately 3 x 8 km in length, is defined by a boundary of up to 150 meters of relief on three of its sides and is perforated in its southeast corner. A series of old lava flows are visible along the southwest portion of the caldera and are identified on the overview figure of Axial Seamount by a blue box. The presence of these lava flows are indicative of a series of volcanic eruptions that have been documented in this seismically active region over time. Profile A-A' (yellow line) across the base of Axial Seamount reveals the variety of depth along this seamount, ranging from approximately 1400 meters below sea level at its shallowest point to a maximum depth of 3000 meters along this segment.

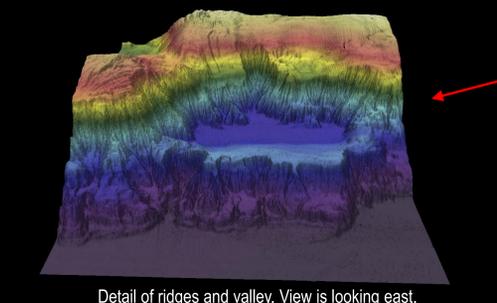


Profile of Axial Seamount segment A to A' as indicating on overview figure by a yellow line. Profile is measured in distance (meters) on x-axis versus depth (meters) on y-axis.

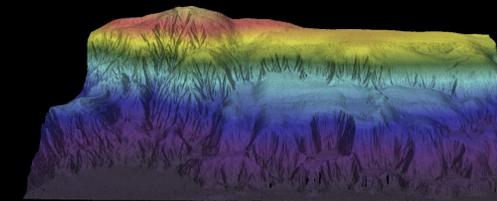
**Figure 3. HYDRATE RIDGE (NODE 1)**



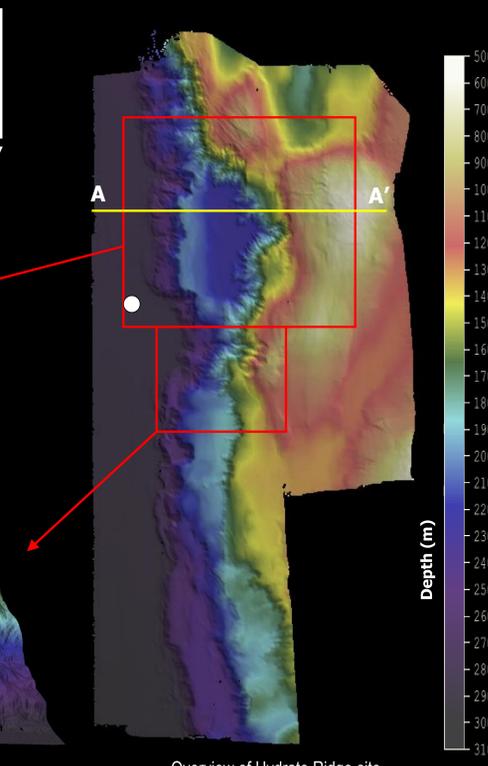
Profile of transect A-A'



Detail of ridges and valley. View is looking east.

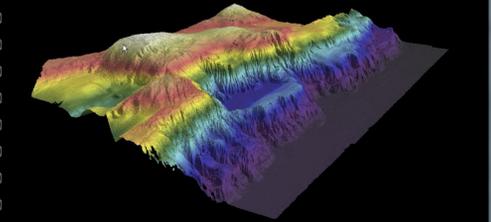


Detail of tectonic front. View is looking east.

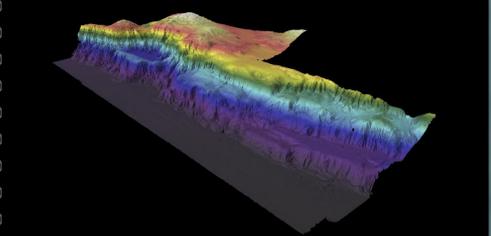


Overview of Hydrate Ridge site  
● = approximate node location

The Juan de Fuca plate is currently being subducted beneath the North American plate at the Cascadia subduction zone. Most of the 3-4 km thick sediment layer of the subducting plate is accreted to North America in this process, resulting in a broad fold and thrust belt on the continental slope. Hydrate Ridge, a north-south-trending peanut-shaped structure, is one of these ridges. Hydrate Ridge is characterized by its 'tectonic front', the massive buildup of sediments along the boundary of the North American continent. The flat abyssal plain, underlain by the Juan de Fuca plate, is located at approximately 3000 meters water depth, while the top of hydrate ridge is located at approximately 580 meters – an elevation difference of about 2400 meters.



3D perspective of entire Hydrate Ridge site, looking southeast.



3D perspective of entire Hydrate Ridge site, looking northeast.

### ACKNOWLEDGEMENTS

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