ESO NEWS

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Neptune Canada

On Tuesday 8 December 2009, NEPTUNE Canada went live, allowing people everywhere in the world to access realtime and archived data via the Internet. This is a major step on the development of Ocean Sciences.
NEPTUNE Canada is building the world's first **regional-scale underwater ocean observatory** that plugs directly into the Internet. People and Ocean Scientists will be able to run deep-water experiments from labs and universities anywhere around the world, reinventing Ocean Science for the 21st century!

The text below was adapted from Neptune-Canada Website.

A new approach to Ocean Science

NEPTUNE Canada is designed by scientists for scientists to address some of the key challenges and questions in the oceans. With continuous data, interactive laboratories and remotely operated vehicles (ROVs) positioned in multiple sites spanning a full range of marine environments, the NEPTUNE project's unique design allows researchers to study processes previously beyond of the capabilities of traditional oceanography. The wide array of instruments allows direct study of geological, physical, chemical and biological systems in the ocean. This interdisciplinary approach will enable researchers to answer some of the most complex and pressing questions of ocean and earth science today.

Dynamics of a tectonic plate

The **Juan de Fuca Plate**, smallest of **Earth's 13 major tectonic plates**, is ideally suited for study because of its size and close proximity to Vancouver Island. The NEPTUNE Canada network will span this plate with instrumentation at strategic locations on the plate's active edges and relatively stable interior.

The Climate and greenhouse gas cycling

NEPTUNE Canada will advance our understanding of climate change by enabling the study of processes involving carbon dioxide and methane cycling in the ocean.

Ocean productivity

Scientists will be able to monitor physical, chemical and biological interactions involved in primary productivity over a period of decades. This in turn drives bio-chemical cycling through the rest of the food chain.

Marine mammal and fish stocks

Population modeling and resource management will benefit from real-time tracking of migration patterns, behaviors and health indicators.

Non-renewable marine resources

NEPTUNE Canada will enable more accurate assessments of metal deposits, hydrocarbon distributions, and slope stability in our coastal regions.

Episodes, events and catastrophes

Long-term, continuous observations will make it possible to capture data for significant episodes as they occur. Resulting research willhelp scientists improve forecast and warning systems. Examples include:

- extreme weather events
- earthquakes
- volcanic activity
- tsunamis
- submarine landslides
- algal blooms

Origins and limits of life

A great diversity of extremophile life-forms are found in harsh deep-sea environments like the super-heated waters surrounding hydrothermal vents and submarine volcanoes. NEPTUNE Canada will help researchers study life's adaptations to extreme and primitive earth habitats.

Marine Life and Climate Change

Some of the world's most productive bio-zones are found in the mid-latitudes along continental west coasts, where prevailing winds and ocean currents combine to lift deep-sea water toward the surface. Upwelling nutrients support a rich and diverse profusion of marine life. One such area exists off southwestern Vancouver Island. This region plays a critical role in the life cycles of several important fish stocks, including Pacific salmon.

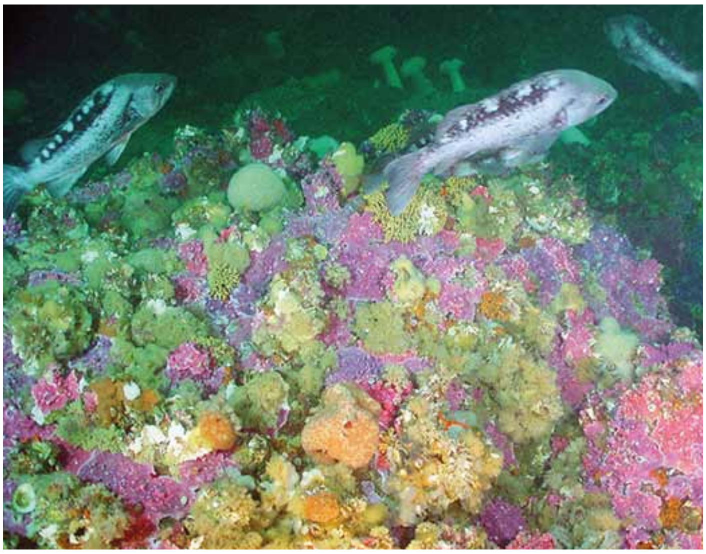


Fig.1 - Observation of Marine life communities

NEPTUNE Canada's seafloor sensor array and vertical water column profiler at the continental shelf break and slope will observe oceanic conditions and their variations as never before. Acoustic and optical sensors will open an unprecedented real-time window to a wide range of physical, chemical and biological processes in the water column. Over time, we will also be able to monitor their evolution related to climate change.

Infrastructure

NEPTUNE Canada's infrastructure is uniquely designed to support real-time cabled observation from multiple instruments and locations distributed across a broad region. Major components of the network are manufactured and installed under a contract with Alcatel-Lucent submarine networks include the backbone cable, branching units and spur cables and major network nodes. Junction boxes, produced by OceanWorks, are connected to the network nodes via extension cables and ODI wet-mate connectors. Each junction box can support multiple instrument platforms, individual instruments and sensors. In addition, power, communications and data processing are handled at our shore station and headquarters facilities.

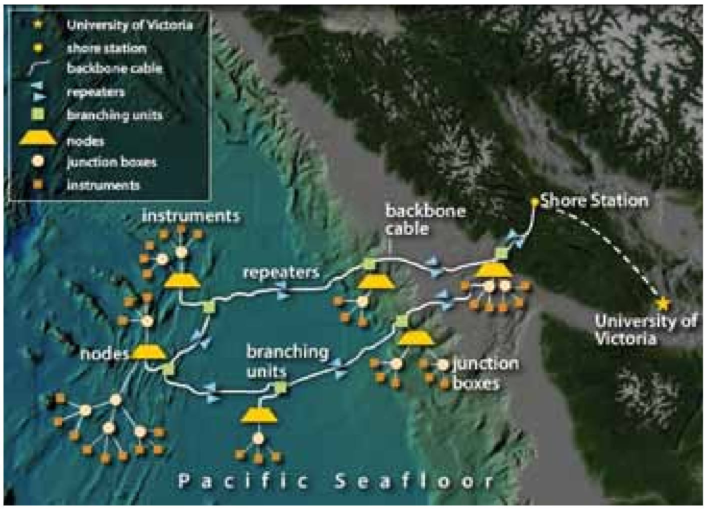


Fig.2 - Basic design of Neptune Canada infrastructure.

Sensors & Instruments

The sensors and instruments deployed across the NEPTUNE Canada network will evolve over time. Old instruments can be removed and new instruments added, often by "plugging in" via wet-mate connectors on nodes and platforms at the seafloor.

Instrument types include:

- conductivity-temperature-depth
- current meters
- hydrophones, sonars, echosounders
- acoustic Doppler current profilers
- bottom pressure sensors
- chemical and gas sensors for measuring carbon dioxide, oxygen, methane, nitrates, etc.
- seismometers, gravimeters and accelerometers
- high-resolution still-frame and video cameras with lights
- microbe and plankton samplers and microbial incubators
- turbidity sensors, transmissometers, sediment traps
- benthic flow simulation chamber

Fig3 - Instruments installed on a platform and ready for deployment in Saanich Inlet, September 2008. From left: hydrophone, rotary sonar, current meter and ADCP. Bottom pressure recorder at base of platform.

Fig.4 - IFREMER's Yves Auffret with Tempo-mini's Aanderaa optode oxygen sensor and temperature probe.

Instrument Platforms

Most instruments in the observatory are either affixed to platforms or connected them by extension cable. Using platforms, instruments can be kept off the seafloor and out of the sediment. Platforms also greatly simplify instrument deployment and recovery, as they are transported between ship and seafloor as single units. During Summer 2009 installation cruises, 9 fixed and 2 mobile instrument platforms were installed. (The mobile platforms are the **Vertical Profiler System** and **Hydrates Crawler.**)

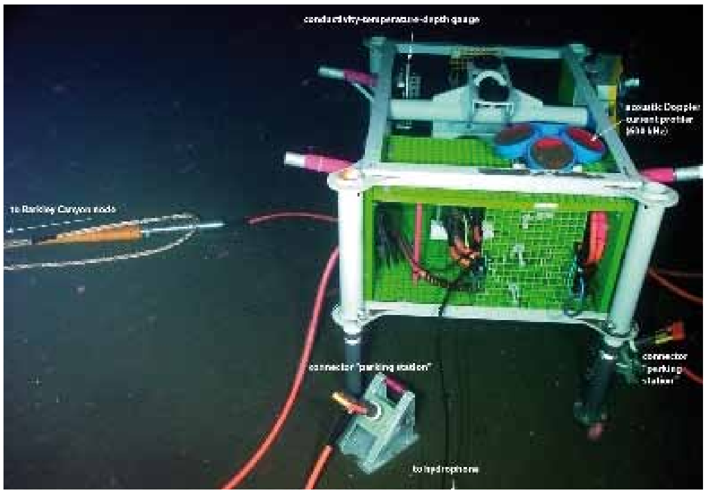


Fig.5 - Barkley Upper Slope insturment platform on the seafloor.

Junction Boxes

The heart of each platform is its junction box, which provides power and communications to the instruments. Incoming 400V DC power can be passed through to secondary instrument platforms or it can be converted to lower voltages (15V, 24V or 48V) required by many instruments. Data streams from the instruments are handled by the junction boxes using either serial or ethernet protocols.

Fig.6 - Connectin of the Neptune Canada junction box

Instrumented Locations

NEPTUNE Canada's backbone delivers power, Internet access and accurate time to five (possibly six) nodes, from which the network will extend via junction boxes to a wide range of instruments. Locations and community experiments were selected after much debate and review to address the key scientific questions within the major research themes for this project.
The NEPTUNE Canada observatory includes five instrumented locations:

1. Folger Passage (Inshore Shelf)

Folger Passage is located on the continental shelf near the entrance to Barkley Sound. Here, instruments will be positioned in two clusters. Folger Passage Deep (95m) on the seafloor and Folger Passage Pinnacle on a rocky pinnacle that reaches up to 17m below the surface.
Main research objectives of this node include (1) the identification of factors controlling biological productivity both within the water column and at the seafloor; (2) the evaluation of the effects that marine processes have on fish and marine mammals and (3) to provide learning opportunities for students, researchers and the public, many of whom will be working and studying at the nearby Bamfield Marine Sciences Centre.
Instruments include at Folger Passage Deep: oxygen sensor, ADCP (300 kHz), echosounder (38, 120, and 200 kHz); bottom pressure recorder; hydrophone (5 Hz - 300 kHz) and CTD. At Folger Passage Pinnacle the following sensors are planned: current meter (2 MHz); light sensor; ADCPs at 600 kHz, 1200 kHz (looking upward), and 2MHz (looking downward); transmissometer;
• video camera; 3-D 8-camera array with lights.

2. ODP 889 (Continental Slope Subduction Zone)

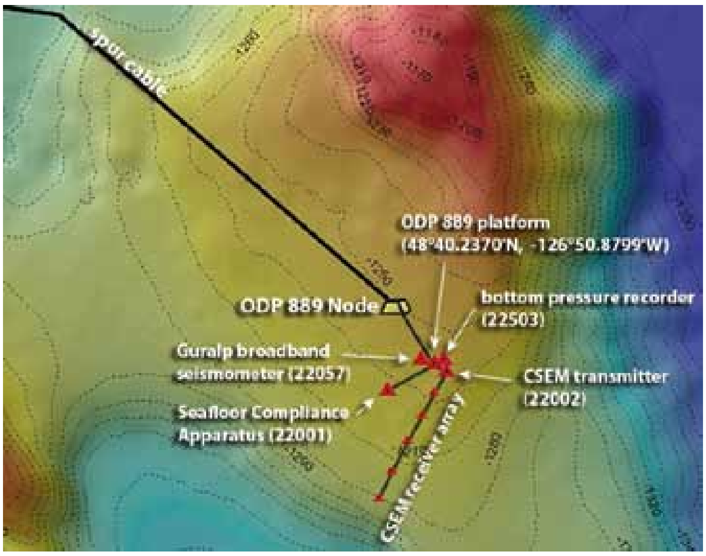


Fig.7 - Design of ODP889 node.

This node is equipped mainly with geophysical instruments. Main Research objectives include the monitoring of changes in hydrate distribution, depth, structure, properties and venting, particularly related to earthquakes, slope failures and regional plate motions.
Instruments installed are the following: controlled source electromagnetic (CSEM) system; seafloor compliance (SFC) apparatus; broadband seismometer (to help pinpoint movements associated with Juan de Fuca subduction zone below); bottom pressure recorder (BPR).

3. Barkley Canyon (Continental Slope Subduction Zone)

Barkley Canyon node was designed to study nutrient and sediment transport from the shelf/slope break through a submarine canyon to the deep sea. In addition, a prominent mid-canyon outcrop of gas hydrates can be studied by marine biologists, geologists, geophysicists, and climatologists.

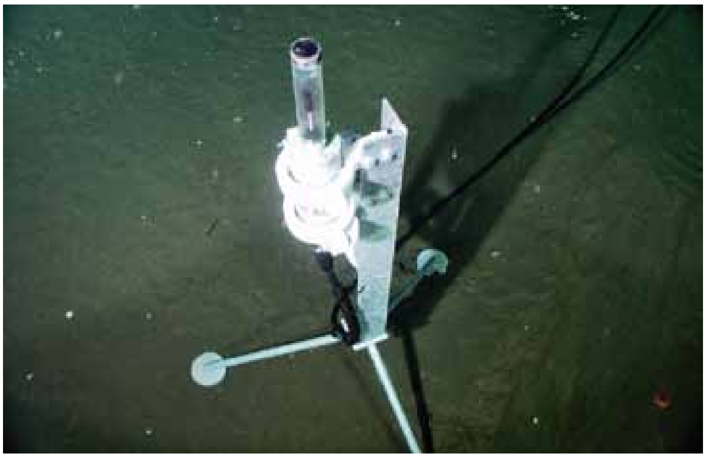


Fig.8 - Barkley Upper Slope hydrophone on the seafloor.

A multi-sensor vertical profiler system was installed at the canyon head. This system consists of a seafloor platform (400m) and a tethered float. A winch on the platform raises and lowers the float through the water column, which bristles with instrumentation for monitoring salinity, temperature, dissolved gases and nutrients, currents, plankton and fish concentrations and marine mammal movements. This system will help scientists examine the influences of complex currents on plankton life cycles. Scientists will be able to study benthic (seafloor) ecology using instrument suites at four study sites along the shelf break, mid-canyon, and canyon axis. A variety of instruments, both on a fixed platform and carried by an remotely operated crawler, will allow detailed study of gas hydrate outcrop accretion and dissolution. Data are now accessible through the Internet.

4. ODP 1027 (Mid-Plate Abyssal Plain)

The ODP1027 site is on the abyssal plain at a depth of 2 660m. Here, NEPTUNE Canada reuses an existing Ocean Drilling Program borehole monitoring systems. CORK systems monitors changes in crustal temperature and pressure, particularly as they relate to earthquakes, hydrothermal convection or regional plate strain. This site will also form part of a plate-wide tsunami detection system that uses highly sensitive bottom pressure recorders to measure tsunami amplitude, propagation direction and speed. Data from this system will complement information gathered by other tsunami sensors around the North Pacific. ODP1027 readings are available at the Internet.
Instruments include: bottom pressure recorders (BPR), broadband seismometer (360s - 50 Hz); CTD; CORK pressure and temperature sensors.

5. Endeavour Ridge (Ocean SpreadingCentre)

Endeavour Ridge node is located at the spreading boundary between the Juan de Fuca and Pacific plates. The region (approximately 300 km off the British Columbia coast), has been the site of intensive investigation for more than 20 years. NEPTUNE Canada's real-time monitoring capability will benefit both ongoing and new experiments. Continuous data gathered before, during and after events like earthquakes and intrusions will be recorded across a coordinated suite of instruments both at the hydrothermal vents on the seafloor and within moorings extending 250m up into the 2,200m water column. A network of seismometers here and at other sites will provide high resolution information on tectonic processes such as earthquakes and strain across the Juan de Fuca plate. This node is still not operational. Tubeworms unfurl their plumes near a hot vent on Endeavour Ridge.

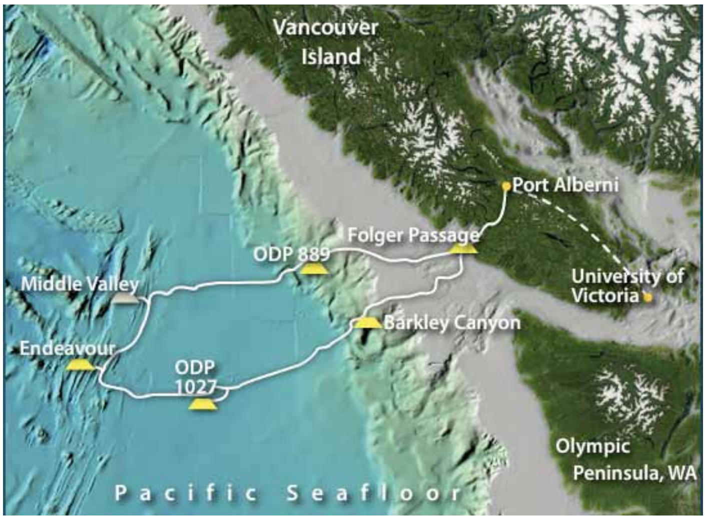


Fig.9 - Mane location for deep seafloor monitoring along the 800kms long cable.

A sixth location will be established at Middle Valley (sedimented portion of the Juan de Fuca Ridge) if further supplementary funding can be secured.

Real-time Data Collection

NEPTUNE Canada is collecting data from 11 instrument platforms and over 50 instruments installed in 4 locations around our 800 km cable loop.

Science Topics

Earthquakes and plate tectonics

Subduction zones like the one along the eastern edge of the Juan de Fuca plate generate some of the world's largest earthquakes, often associated with devastating tsunamis. NEPTUNE Canada's array of sensitive instruments will augment other land-based seismic networks in Canada and the U.S., helping researchers better understand subduction processes and improve their estimates of seismic risk.
Along the western edge of the Juan de Fuca plate, new seafloor is created through plate boundary spreading and volcanic activity. NEPTUNE Canada will install seismometers on the Endeavour segment of the Juan de Fuca Ridge to help pinpoint the many earthquakes that shake that region every year. Closely related phenomena like hot fluid venting and volcanic eruptions will also be studied in conjunction.

Hot vent

Fig.10 - Hot fluids vent from the seafloor in volcanically active Endeavour Ridge. Photo taken from ROPOS by Verena Tunnicliffe and Kim Juniper, 21 August 2002.

Cascadia tsunami

As tsunamis can move rapidly through the open ocean, a large earthquake off British Columbia could send a tsunami crashing into coastal regions in as little as 10-15 minutes.
This computer simulation shows the main wave of the Cascadia tsunami as it crossed the mid-Pacific on 26 January 1700. Severe damage occurred both in coastal First Nations communities in British Columbia and Japan. A similar earthquake is expected sometime in the next 200 years.

Fig.11 - Simulation of 1700 cascadia tsunami generated close to the location of Neptune canada network

Fluid flow in the Seabed

When one tectonic plate pushes under another, sediments are scraped from it to create wedge-like formations along the continental margins. This is happening in western North America's Cascadia Subduction zone, where unique physical and biological processes can be observed. As fluids seep up to the seafloor from deep within the crust, methane and other hydrocarbons in these fluids transmute into ice-like structures called gas hydrates.
At some localities, such as along the edges of Barkley Canyon, gas hydrates outcrop at the seafloor as icy mounds populated by extensive bacterial mats and dense communities of large clams. Elsewhere, the shallowly buried gas hydrates release concentrated bursts of methane, bubbling upward through the water column.

Fig.12 - A small fish eyes ROPOS from its feeding grounds atop a methane hydrate outcrop in Barkley Canyon.

Endeavour Ridge tubeworm community

At Endeavour Ridge, NEPTUNE Canada opens a new viewport into a captivating world of submarine pipes and castles. Here, volcanically heated fluids escape from the seafloor, surging upward into cold deep-ocean waters. As they emerge, the metals and minerals they carry precipitate, forming chimneys up to several tens of metres tall. Venting episodes can be traced to periods of volcanism and faulting. The chemically charged fluids support unique ecosystems, including unusual chemosynthetic bacteria, giant tubeworms, and eyeless shrimp that use photosensitive "patches" on their backs to "see" super-heated water coming from the vents. NEPTUNE Canada will help researchers further their long-term studies of this area's chemistry, geology, geophysics and biology by monitoring the evolution of several vent fields. Ejection of large quantities of hot water from the ridge affects overlying.

Fig.13 - Biologic community in the seabed

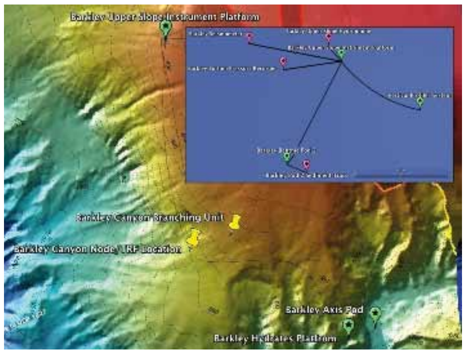
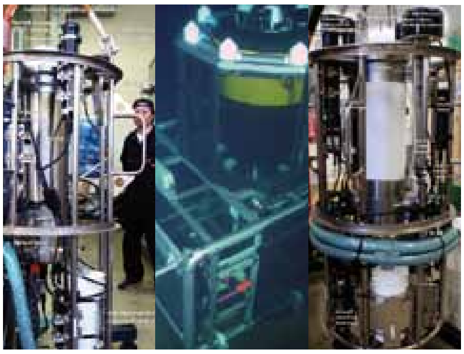
<table>
<tr><td>Platform</td><td>I
On Barkley Upper Slope</td></tr>
<tr><td></td><td>This platform is positioned in an area where the continental shelf begins to slope downward into the deep sea. Two other platforms, the Vertical Profiler System (Platform 3) and Barkley Benthic Pod 2 (Platform 8) are located nearby.</td></tr>
<tr><td>Figures</td><td>

Fig.14 - Overview map showing platforms and instruments in the Barkley Upper Slope area.</td></tr>
<tr><td>Location</td><td>Connected to Barkley Slope/Canyon node on 25 Jul 2009 from the R/V Atlantis.

• Depth: 396.0m
• Lat: 48°25.6474'N
• Lon: -126°10.4747'W
• Heading: 359.0°</td></tr>
<tr><td>Instruments on this platform</td><td>• Seabird Microcat CTD (Conductivity Temperature Depth) sensor
• RDI Workhorse Long Ranger 75kHz ADCP (Acoustic Doppler Current Profiler)</td></tr>
<tr><td>Instruments positioned nearby</td><td>• Broadband seismometer
• BPR (Bottom Pressure Recorder)
• Naxys hydrophone</td></tr>
</table>

2 **The Barkley Hydrates**	3 **Vertical Profiler System**	4 **Hydrates Crawler**
This platform is positioned in the midst of the Barkley Canyon hydrates field, where it provides power and communications to Wally the Crawler and three other instruments platforms (Benthic Pods 1, 3, and 4)	The Vertical Profiler System (VPS) is a mobile instrument platform. It consists of a seafloor base unit and a tethered float. A winch on the base unit raises and lowers the float, which bristles with instrumentation for monitoring: **• salinity** **• temperature** **• dissolved gases and nutrients** **• currents** **• plankton and fish concentrations, and** **• marine mammal movements**	The Barkley hydrates crawler, nicknamed "Wally", is one of two mobile instrument platforms in our network (the other is our Vertical Profiler System). Wally's mission, crawling the hydrates fields in Barkley Canyon, is to help researchers carry out detailed investigations of processes influencing gas hydrates evolution at the seafloor. Wally is connected to the Barkley Hydrates instrument platform via a 70m cable, which provides power and communications. The crawler "crawls" on dual tractor treads, which allow a full range of forward, backward and turning movement. Including its titanium frame, drive motors, sealed electronics chambers, wiring, lights, HD video camera, and sensors, the unit's out-of-water weight is 275 kg. With syntactic foam floatation blocks attached, this is reduced to an in-water weight of 40 kg. One unique feature is its control interface, which plugs directly into the Web. If all works out as planned , you'll one day be able to tune in to a live sea floor crawl on the NEPTUNE website.
 Fig.15 - Brakley Hydrates Platform	 Fig.16 - Vertical Profilers Float Instruments and Team	 Fig.17 - Hoisting ROPOS hoists Wally. Both ready to dive.
Connected to Barkley Slope/Canyon node on 26 Jul 2009 from the R/V Atlantis. **• Depth: 870.0m** **• Lat: 48°18.7266'N** **• Lon: -126°03.9480'W** **• Heading: 253.0°**	The VPS is positioned at a depth of 396m. Cable spooled on the platform is long enough for the float to extend to the surface, allowing scientists to capture data throughout the water column. Connected to Barkley Slope/Canyon node on 25 Aug 2009 from the R/V Thompson. **• Depth: 396.0m** **• Lat: 48°25.6352'N** **• Lon: -126°10.4457'W**	Connected to Barkley Slope/Canyon node on 19 Sep 2009 from the R/V Thompson. **• Depth: 871.0m** **• Lat: 48°18.7164'N** **• Lon: -126°03.9529'W** NEPTUNE Canada is collecting data from 11 instrument
	• Satlantic upwelling radiometer **• Satlantic downwelling radiometer** **• ASL acoustic water column profiler** **• WETlabs Fluorometer** **• Pro-Oceanus CO2 sensor** **• Naxys hydrophone** **• Seabird SBE19plus Conductivity-Temperature-Depth (CTD) sensor** **• Nortek Aquadopp Acoustic Doppler Current Profiler (ADCP)** **• WET labs ECO Backscatter Transmissometer/ fluorom eter** **• Aanderaa oxygen optode** **• Satlantic Nitrate Sensor**	**• current meter** **• methane sensor** **• tilt-compensated compass** **• video camera**
Temperature Probes **Crawler**	The VPS base platform has two cameras and some other sensors associated with the mechanical assembly, but all scientific sensors are affixed to the profiler float unit.	(The hydrates crawler is not connected to any satellite instruments.)

Deep-sea ecosystems

Seafloor ecosystems and those in the overlying water column are intimately connected. NEPTUNE Canada will help researchers study:

- seafloor biological communities
- energy and nutrient pathways
- ecosystem evolution
- ecosystem responses to both short-term and episodic events

A number of sites will be instrumented with acoustic, chemical and optical systems, including video and still cameras, to help scientists learn how seafloor organisms are affected by phenomena like:

- large storms
- El Niño-Southern Oscillation (ENSO)
- Pacific Decadal Oscillation (PDO)
- long-term changes in ocean temperature and salinity
- seasonal upwelling
- canyon processes
- hydrothermal circulations
- Etc.

Fig.18 - Wally Hydrate Crawler in action

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