

Building the World's First Regional Cabled Ocean Observatory (NEPTUNE): Realities, Challenges and Opportunities

Christopher R. Barnes and the NEPTUNE Canada Team

NEPTUNE Canada, University of Victoria, PO Box 1700 STN CSC, Victoria, BC Canada V8W 2Y2
crbarnes@uvic.ca, www.neptunecanada.ca

Abstract - NEPTUNE (North-East Pacific Undersea Networked Experiments) will be the world's first regional cabled ocean observatory, covering most of the 200,000 km² Juan de Fuca tectonic plate. After several years of planning, NEPTUNE Canada should complete the installation of the northern part with five observatory nodes in late 2008; the US Congress may approve 6-year installation funding for NSF's Ocean Observatories Initiative this year, resulting in the NEPTUNE US portion becoming operational in about 2013 with probably four observatory nodes. The abundant power, high bandwidth communications, and hundreds of sensors delivering data and imagery in real or near real time will revolutionize our knowledge of the ocean environment and interacting processes. With the world's oceans in a state of crisis, the development of cabled observatory technology is most timely and will offer a data archive of unparalleled importance for new discoveries.

NEPTUNE Canada has secured over \$85M, mainly from the Canada Foundation for Innovation and the BC Knowledge development Fund, and \$17M in-kind support. Several government departments, NSERC, and CANARIE have provided other grants and contributions. The University of Victoria (UVic) leads a consortium of 12 Canadian universities, and is required both to own and operate the observatory. UVic also leads the coastal observatory, VENUS (www.uvic.ca/venus). It has established Ocean Networks Canada as a wholly owned, not-for-profit agency to manage the NEPTUNE Canada and VENUS cabled observatory projects as national facilities. Alcatel-Lucent was contracted to design, manufacture and install the NEPTUNE Canada subsea infrastructure, with a 25-year lifespan. An 800km loop of backbone cable/repeaters/branching units is being installed in fall 2007 connecting with UVic's Port Alberni shore station, with the nodes added in 2008. NEPTUNE Canada will then install the secondary cables, junction boxes and instruments in late 2008, possibly with some in 2009, followed by testing, security protocols and commissioning.

Significant challenges have been faced with: securing adequate funding; the innovative design of the nodes, junction boxes and vertical profiler; the route survey over challenging topography; building in-house a Data Management and Archive System that also incorporates an observatory control system; periodic reduction in scope and aspirations; and developing collaborative relationships, including those with the Canadian and US navies,

the commercial fisheries, and the First Nations. A series of science workshops during the conceptual design and construction phases, along with external reviews, helped shape a program of community experiments with many focused on the five (with a sixth currently unfunded) sites and others plate-wide in scope. The five principal research themes are: plate tectonics and earthquake dynamics; fluid fluxes in the oceanic crust and gas hydrates in the accretionary margin; ocean-climate dynamics and impact on fisheries; dynamics of the deep sea ecosystems; and engineering and computational research applications.

Opportunities abound for: extending and expanding the network and instrument arrays; international partnerships with other emerging cabled observatories; commercial innovation and demonstration; educational and outreach programming; collaboration with the Ocean Tracking Network project; and nurturing applications/technologies for monitoring pollution, port security, linking offshore oil fields, renewable resource management, and using the long time-series of data essential to improve public policy formulation. NEPTUNE Canada invites researchers, educators, institutions, international partners, and industry to consider participating in the observatory (neptune@uvic.ca; www.neptunecanada.ca).

I. The NEPTUNE PROJECT: SCOPE, ORGANIZATION AND CONCEPT

This paper attempts to discuss some of the realities, challenges and opportunities associated with conceiving, funding, installing and operating the world's first regional cabled ocean observatory: a new science megaproject. NEPTUNE (North-East Pacific Undersea Networked Experiments) will be an innovative network of many sub-sea observatories linked by about 2000-3000 km of powered, electro-optic cables covering much of the Juan de Fuca Plate (200,000 km²), North-east Pacific, with shore stations at Port Alberni, British Columbia and probably Nedonna Beach, Oregon (www.neptunecanada.ca, www.orionprogram.org, www.ooi.washington.edu). Each observatory, or node, will host and power many scientific instruments on the surrounding seafloor, in boreholes in the seafloor, and buoyed through the water column. Remotely operated and autonomous vehicles will reside at depth, powered and

recharged at observatories and directed from distant labs. Continuous near-real-time multidisciplinary measurement series will extend over 25 years.

Major research themes being addressed by NEPTUNE Canada include: structure and seismic behavior of the ocean crust; dynamics of hot and cold fluids and gas hydrates in the upper ocean crust and overlying sediments; ocean/climate change and effects on ocean biota/fisheries at all depths; deep-sea sedimentation, ecosystem dynamics and biodiversity; and engineering and computational systems research. These involve interacting processes, long term changes, and chaotic, episodic events that are difficult to study and quantify by traditional means.

The NEPTUNE Project is a bi-national science megaproject with an estimated total infrastructure installation cost of about \$250M and an anticipated annual operating cost of about \$20-25M. The University of Victoria (UVic), BC, leads the Canadian program with a consortium of 12 universities across Canada and participation by many federal research laboratories. The US program is funded by the National Science Foundation (NSF), which has established the ORION Project Office and the Ocean Observing Initiative (OOI). The Office established the University of Washington as the Implementing Organization (IO) to manage the US portion of the Regional Cabled Observatory, or Regional Scale Nodes (RSN; with this name replacing NEPTUNE in OOI), installation and initial operation in March 2007. In 2004, UVic and NSF signed a Memorandum of Understanding (MOU) to cooperate in installing the NEPTUNE interoperable observatory network.

How was such a bold project conceived and developed? The development of powered, high bandwidth fibre optic cables by the telecommunication industry was recognized as a new potential to connect to oceanographic instruments for scientific purposes. A number of decommissioned cables in Japan were modified to attach seismometers and other sensors to aid in earthquake detection and tsunami warning systems. In the US, scientists including John Delaney (University of Washington) and Alan Chave (Woods Hole Oceanographic Institution) began to develop the concept of cabled observatory networks of different scales. In particular, the concept focused on instrumenting a tectonic plate and settled on the smallest of the world's twelve plates: the Juan de Fuca plate in the North East Pacific, that lay offshore two well-developed nations (US and Canada). A group in British Columbia, Canadian Ocean Frontiers Research Institute (COFRI) was seeking to promote large oceanographic projects that would integrate the interests of the academic, government and industry sectors. COFRI and two other organizations merged into the Pacific Institute for Science and Technology (IPOST). IPOST hosted a meeting at Emerald Lake, BC, in 2000 where US and Canadian scientists agreed to work together to develop the concept and funding for a regional cabled ocean observatory that would cover the Juan de Fuca plate: the NEPTUNE Project.

A Memorandum of Understanding was developed and it was agreed that the US and Canadian groups would attempt to

raise funds on an approximate 70:30 ratio that reflected their respective national EEZ areas over the plate. The main institutions involved were IPOST and the University of Victoria in Canada and the University of Washington, Woods Hole Oceanographic Institution, Monterey Bay Aquarium Research Institute, and NASA's Jet Propulsion Laboratory at Cal Tech in the US. Many meetings resulted in a variety of funding contributions that allowed a number of scientific workshops to forge a process to define the range of potential experiments that could be undertaken with such a cable observatory. Thus, the Concept Phase evolved during 2000-2003; the series of events, major meetings, conferences and reports, and publications are listed at: www.neptune.washington.edu/about/index.jsp?keywords=HISTORY&title=History. A change to the Installation Phase was only possible with successful funding applications: VENUS and MARS in 2003, NEPTUNE Canada in 2003 and 2006, and the OOI expected in 2008 as detailed in the next section.

II. THE CHALLENGE OF SECURING FUNDING SUPPORT

Having translated the vision into a formal concept proposal, the next major challenge was securing major infrastructure funding. Within Canada, there was not a formal process or program for evaluating and funding Big Science projects. A period of active solicitation to industry, the federal granting councils and science departments failed to identify a suitable source of funding. After the decade of the 1990s when university infrastructure suffered through lack of support, the federal government established the Canada Foundation for Innovation (CFI). In turn, it created a one-time International Access Fund of \$100M to bring a few areas of science to truly international competitiveness. NEPTUNE Canada submitted a successful application and received \$31.9M; to meet the shortfall, the British Columbia Knowledge Development Fund (BCKDF) provided a match of \$30.5M. These awards were announced in October 2003 and allowed NEPTUNE Canada to move forward with its portion of the Juan de Fuca observatory array.

NEPTUNE and the associated VENUS (Victoria Experimental Network Under the Sea) and MARS (Monterey Accelerated Research System) ocean observatories will use most of the same cable and similar engineering systems with the latter two also acting as shallow and deep-water test-beds, respectively, for the former.

The VENUS coastal test bed (www.venus.uvic.ca) was funded at \$10.3M (all dollar amounts in the text are given in Canadian dollars unless specified as US\$) jointly by CFI and BCKDF in 2002 and is led by UVic with Verena Tunnicliffe as Project Director. Its first line was installed in Saanich Inlet in February 2006 and the other line across much of the Strait of Georgia will be added in mid-2007 in waters less than 300 m deep.

MARS (www.mbari.org/mars/) will be installed near the Monterey Canyon, California, at 900 m water depth and 50

km offshore in late 2007 or early 2008 by the Monterey Bay Aquarium Research Institute (MBARI). Funding from mainly the National Science Foundation and other foundations (c. \$12M) was secured in 2002.

NEPTUNE began to take shape as an US/Canada partnership (probably 60:40 funding ratio) with over \$30M already having been funded by US agencies in 2000-2003 (e.g., by NSF) for power and communications design. NEPTUNE Canada proceeded to issue a RFQ and a RFP for the design, manufacture and installation of the subsea infrastructure (cable/nodes). In October 2005, UVic signed a contract valued at nearly \$39M with Alcatel Submarine Networks (now Alcatel-Lucent). The scope proved to be less than initially desired partly because of the non-recurring engineering costs borne mainly by Canada. A further request to CFI and BCKDF provided an additional \$20M award in that enlarged the scope from two to five nodes. With additional grants of over \$4M and in-kind support of over \$17M, the total funding secured by NEPTUNE Canada now approximates to \$100M. VENUS and NEPTUNE Canada will thus form a linked coastal/regional ocean observatory system, and be among the first of many such cabled ocean observatories.

There has been a delay of several years in the US in securing major funding. US funding, including MARS, has totaled about \$40M to date, with the major funding of \$331M/6 years for the Ocean Observatories Initiative (OOI) now under consideration by the US Congress, probably to start in Fiscal Year 2008. The National Science Foundation (NSF) established the ORION Project Office in 2004 to manage the proposed US\$331M infrastructure budget to cover observatory installation costs for coastal, regional and global-buoy observatory facilities. This funding would come from the Major Research Facilities, Engineering and Construction (MREFC) account after approval by Congress. These would be new resources, similar to the US\$116M just announced by NSF for the refit of the *Resolution* as part of the US commitment to the new Integrated Ocean Drilling Program (IODP). Herein, the Canadian portion of the NEPTUNE observatory is referred to as NEPTUNE Canada, with the US portion called Regional Scale Nodes (RSN, as desired by OOI).

Other regional ocean observatories are being planned in Japan (DONET), Taiwan (MA'CHO) and around Western Europe (ESONET). NEPTUNE Canada is arranging MOUs with all of these and will have a staff exchange and instrument deployment from Ifremer, France, in 2007-08. It is emphasized that we are entering a new age of wiring the oceans with the potential to have large-scale, interdisciplinary, interactive, real-time experiments.

III. NEPTUNE CANADA DEVELOPMENTS: CHALLENGES IN PLANNING AND INSTALLATION

NEPTUNE Canada is a consortium of 12 Canadian universities (Memorial, Dalhousie, Rimouski, Laval, UQAM, Toronto, Guelph, Waterloo, Manitoba, Simon Fraser, UBC,

and Victoria), led by UVic.

Under the terms of the CFI/BCKDF awards, UVic is required to both own and then operate the observatory for at least the first five years. UVic has provided new space for NEPTUNE Canada, VENUS and Ocean Networks Canada to be co-located on campus. After receiving news of its funding in late 2003, NEPTUNE Canada has been developing rapidly and currently has a full-time staff of 22 with others under contract. It has made three major funding commitments: for the wet plant infrastructure, for the scientific instruments supporting the community science experiments and for the in-house development of the Data Management and Archive System (DMAS). In October 2005, UVic signed a contract valued at nearly \$39M with Alcatel Submarine Networks (ASN; now Alcatel-Lucent) to design, manufacture and install the wet plant infrastructure (cable and nodes) for NEPTUNE Canada with a further \$10M in late 2006 for extra nodes. Major subcontractors in the project include Texcel Technology, L3 MariPro, Alcatel-Lucent Canada, NGK and OceanWorks.

This installation (see map of cable route and node locations, Fig. 1) will involve an 800km cable loop from UVic's shore station at Port Alberni, purchased in 2004 (Fig. 2), out to the Endeavour Ridge.

Five instrumented observatory nodes (Fig. 3) will be located at 1) inshore Folger Passage, the slope sites of 2) ODP (Ocean Drilling Program) 889 and 3) Barkley Canyon, 4) the mid-plate ODP 1027 site, and 5) the ocean spreading site at Endeavour Ridge. A sixth node will be established at Middle Valley (sedimented portion of the Juan de Fuca Ridge) if

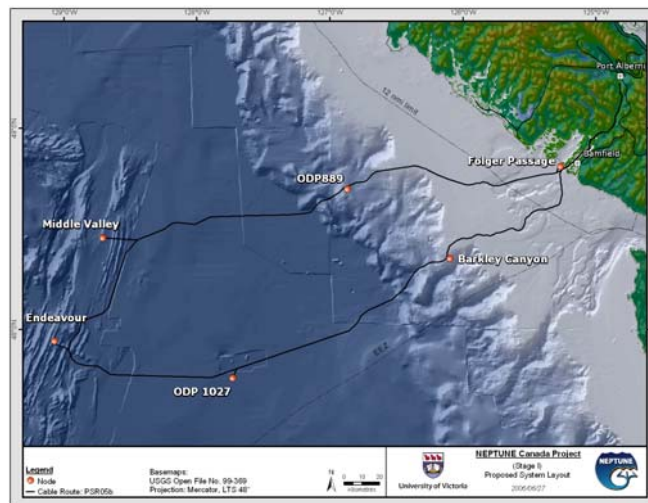


Figure 1. NEPTUNE Canada map showing cable route, and node and shore station locations.

further supplementary funding can be secured. At this point, a branching unit and spur cable will be installed at Middle Valley to allow later addition of the node and instruments.

Alcatel-Lucent manufactured the cable in Calais, France, and will install it and the Branching Units, repeaters and spur cables in 2007 (August-October). The nodes are being designed and manufactured by Alcatel-Lucent, with L3

MariPro in Santa Barbara, California, and will be deployed in 2008. NEPTUNE Canada is responsible for deploying the secondary cables, junction boxes and instruments, expected to be accomplished in late 2008 (some possibly into 2009) after full testing and commissioning (Fig. 4). Alcatel-Lucent also earlier won the contract to install the MARS observatory, with L3 MariPro as a subcontractor.

Technical details of the infrastructure are provided by the papers by Phibbs, Lentz and Jones elsewhere in this MTS-IEEE Oceans 07 proceedings volume, with a paper covering the details of the science program by Best.



Figure 2. NEPTUNE Canada's shore station at Port Alberni



Figure 3. ROV serviceable science node being lowered into trawl resistant frame (MARS node by L3 MariPro)

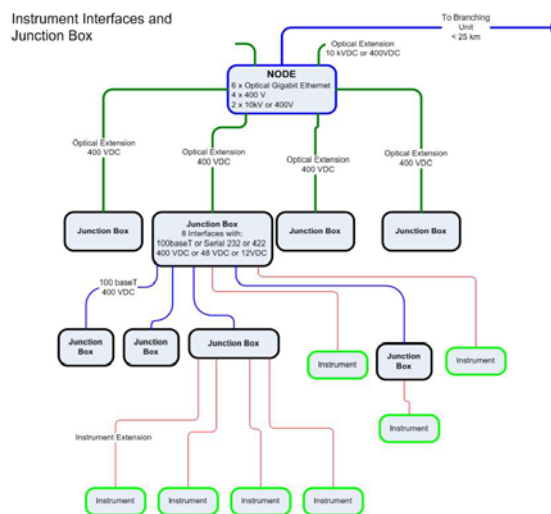


Figure 4. Instrument Interfaces and Junction Box



Figure 5. Alcatel-Lucent's Ile de Sein cable ship, 140 m in length, which is installing the backbone in fall 2007

IV. NEPTUNE CANADA DEVELOPMENTS: SCIENCE EXPERIMENTS AND INSTRUMENTATION

Brian Bornhold and Kim Juniper (initial Co-chief Scientists) have led the exhaustive analyses of the proposals and the required compromises; the details of the first \$7M awarded for instruments, extension cables, interface modules, and installation are listed in the October 2005 Newsletter at www.neptunecanada.ca. With the supplementary \$20M, a further \$6M is being devoted to additional scientific instruments and connectivity costs. With the increased work to deal with about 120 instruments representing a few hundred sensors, NEPTUNE Canada appointed Dr. Mairi Best as Associate Director Science in late January 2007, with Brian Bornhold continuing as Project Scientist and Kim Juniper accepting a research chair at UVic. Many of the instruments require development work, followed by bench and wet testing prior to deployment, coordinated by Paul Hansen (Manager,

Project Quality Assurance) and others using the Saanich Inlet VENUS node. Science workshops in mid-November 2006 further defined formal agreements for the acquisition, development and specifications for the instrumentation requested. We are also receiving further requests to add instruments by other scientists funded from other sources. The approved community science experiments and the main instruments/sensors being deployed are summarized as follows (see the paper by Best in this volume for more specific details).

A. Endeavour Segment of Juan de Fuca Ridge

1) Monitoring Hydrothermal Systems

The Endeavour team will deploy instruments at two of the five vent fields on the Endeavour Segment of the Juan de Fuca Ridge – at the Main Endeavour Field and Mothra. Many of the instruments are those that have been used at the site in recent years by researchers from the University of Washington and will be modified to become network compatible. These include temperature-resistivity-hydrogen probes, microbial incubators and short-period seismometers.

At the Main Endeavour Field, temperature-resistivity probes, a microbial incubator, a high-resolution digital camera (or HDTV) and a McLane fluid sampler will be installed. At the Mothra Field, a temperature-resistivity probe, a microbial incubator, a McLane fluid sampler and a high-resolution digital camera will be deployed.

A regional circulation experiment, to characterize hydrothermally driven water mass movement, will set out four mooring arrays extending 250 m up into the water column. The instrumentation will consist of acoustic three-dimensional current meters situated at 10, 50, 125 and 250 m above the seafloor. With each current meter will be a sensor to measure temperature and salinity variations. One bottom pressure sensor will be deployed to accurately measure local tides.

University of Washington's existing short period seismometers at Endeavour Ridge will be refurbished and redeployed to continue the time series of seismic observations that have been ongoing for several years. As well a broadband seismometer will be deployed in the vicinity of the ridge to characterize the overall seismicity in the area in order to understand linkages between local tectonics and other biological and oceanographic phenomena being investigated by the Endeavour Ridge Monitoring Experiment.

A bottom pressure recorder (BPR) will be deployed near Endeavour Ridge as part of the tsunami monitoring network.

B. Barkley Canyon Region

1) Hydrates

Various instruments will be deployed in the vicinity of the known outcropping gas hydrates along the northwest wall of Barkley Canyon in order to understand better the accretion and degradation of the hydrate mound structures as well as changes in biological and chemical activity in the area. The sensors will include in situ temperature probes to depths of one metre or more, three rotary still cameras deployed near the

known mounds and a "crawler" developed by the International University Bremen. The tracked crawler will carry a CTD, methane sensor, a Schlieren optical system, a webcam to control vehicle movements, a video system to quantify gas bubbles and possibly oxygen sensors or a benthic flow simulation chamber to study particle dynamics.

2) Biophysical Linkages off Vancouver

The aim of the "water column" experiment is to develop a better understanding of the coupling between the physics and the biology off southwestern Vancouver Island and how this coupling relates to variability in oceanographic processes and responds to long-term climate change. The instrumentation will consist of a water column profiler being designed and manufactured by NGK, Japan, to be located in about 400 m water depth on the continental slope about 8 km to the north of Barkley Canyon. Profiles of water properties will be acquired through the entire water column. This profiler will be equipped with a CTD, oxygen sensor, fluorometer, transmissometer, nitrate sensor, carbon dioxide sensor, a multi-frequency acoustics package and an upwelling/downwelling radiometer. As well, bottom-mounted instruments will consist of an upward-looking 150 kHz ADCP and a pressure sensor.

3) Role of Disturbance in Deep Sea Benthic Ecosystems

This benthic ecology experiment focuses on the region near Barkley Canyon and is designed to interface with the "water column" team working in the same area to examine changes in benthic communities related to the transfer of energy and nutrients from the water column to the seafloor, as well as through the canyon, in this highly productive area characterized by seasonal upwelling. Equipment will be deployed at four separate sites along the northwestern side of Barkley Canyon as well as within the axis; the latter is to investigate downslope transfer of sediments through the canyon. One instrument "pod" will be located near the vertical profiler to be installed by the water column research team.

Instrumentation will consist of acoustic current meters, sediment traps, rotary sonar systems, plankton pumps, video cameras, high-resolution still cameras, CTD with fluorometer, microbial metabolic sensor package and laser optical plankton counter. It is hoped that a hydrophone deployed in the vicinity of the canyon that will be able to detect slope failures in the area as well as marine mammals.

C. Folger Passage, Barkley Sound

1) Physical and Biological Oceanography

The Folger Passage site is located near the entrance to Barkley Sound, about 10 km west of the Bamfield Marine Science Centre. The site will consist of two installations, one in about 95 m water depth and another near the summit of a rocky pinnacle in about 15 m water depth. The overall objectives of the scientific initiatives at this nearshore location are to: identify the factors that control biological productivity, both within the water column and at the seafloor; evaluate the

effects that marine processes have on fish and marine mammals; and to provide learning opportunities for students, researchers and the public.

The deep-water instrument package will consist of an ADCP (Acoustic Doppler Current Profiler), a multi-frequency bioacoustic sensor, an oxygen sensor, and a temperature/salinity sensor. A hydrophone will be installed at this location to detect and characterize marine mammals in the region. The pinnacle instruments will include a 3-D array of cameras to examine the response of rocky reef organisms to environmental variability, upward- and downward-looking high-frequency ADCPs and a light sensor. The Folger Passage site will be complementary to the water column site on the continental slope in about 400 m water depth where a vertical profiler will collect a variety of water property and biological data. Close proximity to the Bamfield Marine Science Centre will allow regional oceanographic information to be collected on a regular basis near the Folger Passage instrument arrays.

C. ODP Site 1027

2) *Hydrologic Regime in Oceanic Crust, Tsunami Monitoring, Benthic Ecology, Seismicity*

At Site ODP 1027, on the abyssal plain in 2660 m water depth, the principal focus is on connecting the existing Ocean Drilling Program borehole monitoring systems to the observatory. Circulation obviating retrofit kits (CORKs) were instrumented at two holes in 1996 and an additional two holes in 2002; the holes extend tens to hundreds of metres into the igneous seafloor through a sediment cover of a few hundred metres. The objectives of this program are to monitor changes in crustal temperature and pressure particularly as they relate to events such as earthquakes, hydrothermal convection or regional plate strain. It is planned to connect two CORKs to NEPTUNE Stage I.

In addition, a triangular array of very sensitive bottom pressure recorders (BPRs) will be deployed in the area of ODP 1027 as part of the tsunami array that will include BPRs at most of the science locations. This array will extend 10 km on each side and will allow determination of open ocean tsunami amplitudes, propagation direction and speed. The NEPTUNE tsunami array will complement other information from buoy sensors and coastal tide gauges around the North Pacific, and contribute to our knowledge about how tsunamis (and similar large waves) behave, as well as providing real-time monitoring of the phenomena.

Nearby, at Baby Bare, a small outcrop of igneous seafloor, we plan to install a broadband seismometer with associated hydrophone and a single-point current meter. Close by, a benthic ecology program, consisting of high-resolution still cameras, rotary sidescan sonars, an ADCP and a CTD will be installed. Baby Bare is a site of slow fluid venting from the seafloor and, as such, may prove to be biologically of great interest located within this expanse of broad flat abyssal plain sediments.

D. ODP Site 889

1) *Shallowly Buried Gas Hydrates on the Continental Slope*

Site ODP 889 is located on the continental slope in about 1250 m water depth in a well-studied area characterized by shallowly buried gas hydrates. Initially most instruments will be deployed in the Bull's Eye area and will consist of several suites of geophysical instruments, including a controlled source electromagnetic (CSEM) system and receiver, a seafloor compliance system (gravimeter) and a geophone array. The objectives of this investigation are to monitor changes in the hydrate distribution, depth, structure and properties, particularly in relation to earthquakes and regional plate motions. A broadband seismometer, and associated hydrophone and single-point current sensor will be also located nearby, as will a bottom pressure recorder as part of the tsunami array. At present no ODP boreholes in the area are equipped with CORKs; it is hoped that in the future, with the additional drilling that is planned for the area, CORKs can be installed and connected to the network can be installed to complement these other studies of gas hydrates and fluid fluxes on the continental margin.

E. Saanich Inlet

1) *Science Support Test Bed*

It was recognized that many of the newly developed instruments would require rigorous field testing prior to long-term deployment on the deep ocean on the NEPTUNE observatory. As a result an award was made to establish and operate a test facility associated with the VENUS site in Saanich Inlet. Colin Bradley (UVic) has received a CFI/BCKDF award (\$2M) to further develop this test facility.

V. ROUTE SURVEY CHALLENGES

NEPTUNE Canada provided Alcatel-Lucent with the necessary detailed route surveys for the cable/nodes. The cable route involves complex topography that a normal telecommunications deployment would try to avoid but is where the scientific investigations are most needed. Cheryl Katnick (Manager, Permits and Rights of Way) has been compiling all available data along the 800 km route from many sources, especially from the University of Washington. Additional survey work has been necessary and much of this was accomplished in Fall 2005. The University of Washington's *R/V Thompson* was used for a month-long cruise to the Endeavour Ridge, led by John Delaney and Deborah Kelley. NEPTUNE Canada and NSF provided funding to ensure that the *Autonomous Benthic Explorer* (ABE/AUV, from WHOI (Woods Hole Oceanographic Institute)) was available to undertake systematic sea-bed mapping to facilitate the task of laying the cable along the narrow Endeavour rift valley and using the *Jason 2* remotely operated vehicle (ROV) for specific photographic imagery (including HDTV). Adien Aggenbach (cable routing consultant) was on board for part of the period as the NC route engineer. Aggenbach, Bornhold and Juniper participated on other vessels to complete two surveys across the shelf,

including surveys with the ROPOS remotely operated vehicle and cone penetrometer tests, totaling over 1000km. A further ROPOS expedition on the *R/V Thompson* occurred in August 2007 to survey the Endeavour, ODP 889 and Barkley Canyon instrument locations and recover seismometers for interfacing to the network. A major effort is underway to convert all the survey data into GIS (Geographical Information System) format.

VI. DATA MANAGEMENT AND ARCHIVE SYSTEM (DMAS): AN IN-HOUSE DEVELOPMENT

NEPTUNE Canada has added new staff to develop the Data Management and Archive System (DMAS). Good progress has been made by the team led by Benoît Pirenne (Associate Director for Information Technology) on the interim DMAS for the VENUS project that is serving as a prototype for the needs of NEPTUNE Canada. About \$1M was awarded through the CANARIE Intelligent Infrastructure Program (CIIP), in partnership with IBM, to develop Web Services and to turn our software infrastructure into a Service-oriented Architecture (SOA) to control all the remote sensors from distant research labs. A parallel \$1M award to John Roston, McGill University, in partnership with NEPTUNE Canada, VENUS and FlexMet Inc, developed software solutions for controlling the use and communication systems for high definition TV from deep ocean environments. DMAS successfully passed through a Preliminary Design Review in June 2006 and a Critical Design Review in March 2007 (see website for details).

New functionality to access imaging, acoustic and video data or navigate the observatory components will be released progressively on the web site. As a technology demonstration, DMAS has also invested in MBARI's Automated Visual Event Detection (AVED) software, which will be adapted to automatically detect features in underwater video material, perform a classification and return results for inclusion as new metadata in our database. While AVED will be linked to DMAS through Web Services, it is anticipated that it will be run on GRID nodes outside of NEPTUNE Canada's direct IT infrastructure. A first implementation/adaptation of AVED should be installed within the next few months. Similarly, feature detection and classification in hydrophone data streams will soon be possible: The use of the Marsyas software developed under the leadership of Dr. Tzanetakis at the University of Victoria will be shortly made available through DMAS.

A DMAS "vision" workshop proposed a variety of practical examples of suggested software features, which include the ability to subscribe to data streams of selected sensors, the detection of user-specified events, the precise time-tagging of measurements, the ability to interact directly with instruments, to program instruments to react to scheduled or unscheduled activities, the ability to accurately report issues with instruments, to provide pre-processed data (e.g., hourly or daily averages), to provide a geographical interface (GIS)

access to the data and to support links to other databases. Further details on DMAS development are included in the paper by Leslie and Pirenne in this proceedings volume

VII. OTHER INTERACTIONS

In such a complex project, it is not unexpected that one of the management realities is the wide variety of interactions that need to be established. Regular meetings are held, for example, with several First Nations councils and representatives.

Both the Canadian and US navies have operational interests in the area, with most of the US submarine fleet based out of Puget Sound, Washington State, and transiting through the Strait of Juan de Fuca and across or near the NEPTUNE Canada observatory loop. NEPTUNE Canada established a CyberSecurity Committee with representatives from both navies to try to ensure a balance between scientific objectives and national security interests.

The shelf and upper continental slope areas within the observatory footprint is regularly fished by trawl and hook-and-line methods and we are endeavouring to limit the physical interactions between fishing gear and scientific instruments and infrastructure (cable, nodes). NEPTUNE Canada established a Fisheries Advisory Committee, with representatives of the several different fisheries and from the relevant federal and provincial government departments.

On scientific matters, NEPTUNE Canada management seeks guidance from its Science Advisory Committee.

VIII. SUMMARY

The NEPTUNE Canada Project is entering the last year in the installation phase of constructing the world's first regional cabled ocean observatory. It is part of a joint US/Canada program, the later part will be to add the US component to the south and thus cover much of the 200, 000 km² Juan de Fuca tectonic plate. NEPTUNE Canada has advanced from a variety of planning and design efforts to allocating most of its \$80M cash and \$20M in-kind support budget for defined acquisitions and technological developments. The 800km cable installation is occurring in August-October 2007. The five nodes and hundreds of sensors should be deployed in 2008. The observatory array is expected to be fully operational in late 2008. As the main US funding for the Ocean Observatories Initiative (OOI) has not yet been approved by Congress, the Canadian and US regional observatories will probably be installed four to five years apart. NEPTUNE Canada and its principal contractor Alcatel-Lucent, and principal subcontractors Texcel Technology and L3 MariPro, are playing a leading role in the advent of the new technologies for cabled ocean observatories that will transform the ocean sciences. This applies to other companies such as NGK with the vertical profiler and OceanWorks with the junction box development. Scientists or companies/institutions interested in joining the experiments or in adding instruments to the arrays are urged to contact NEPTUNE Canada (neptune@uvic.ca).

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