

NEPTUNE Canada



Feasibility of Canadian Participation in the NEPTUNE Undersea Observatory Network

Report prepared under the direction of:
Canadian NEPTUNE Management Board



On behalf of:
Institute for Pacific Ocean Science & Technology
200 – 2150 West Broadway, Vancouver, BC V6K 4L9

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FOREWORD

Small variations in the Earth's orbit are enough to trigger an ice age. A single volcanic eruption can have major impact on worldwide weather patterns over several years. It cannot be surprising therefore that the activities of mankind are significant enough to have major long-term effects on our environment.

We now know that our oceans play a major role in mediating and moderating the effects of mankind on our environment. We know they cover about 70% of the planet, and that they have a critical role to play in the carbon cycle, as well as in the distribution of temperature and weather around the globe. With the advent of earth-observing satellites our knowledge of ocean currents, ocean temperature, plankton distribution and many other important variables related to ocean surfaces has increased enormously. However, our knowledge about the seabed and most of the water columns above it is episodic at best, and lacks any systematic capability to observe changes over time.

Our oceans and our seabeds have truly become our last critical knowledge frontier, and arguably our principal scientific challenge for the next 50 years. Without a greater understanding of deep ocean and seabed phenomena, our ability to predict the impact of both natural and man-initiated changes in global variables such as carbon dioxide concentration, storm frequency and severity, temperature, food fish survival rates, subsea energy resources and pollution will be severely limited.

Implementation of the proposed NEPTUNE undersea observatory network will move us a giant step forward. By selecting a small but very important corner of the Pacific Ocean to study in depth we gain not only valuable knowledge about this region, but we open the door to the much larger issue of gaining a deeper understanding of the critical processes in and under all our seven seas.

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Chair, Canadian NEPTUNE Management Board
Vice Chair, Institute for Pacific Ocean Science & Technology

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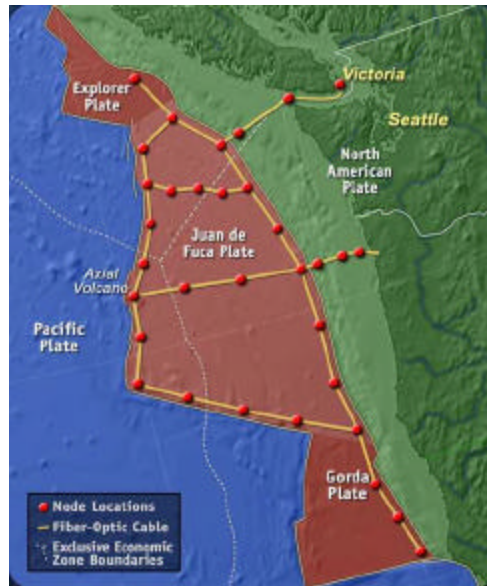
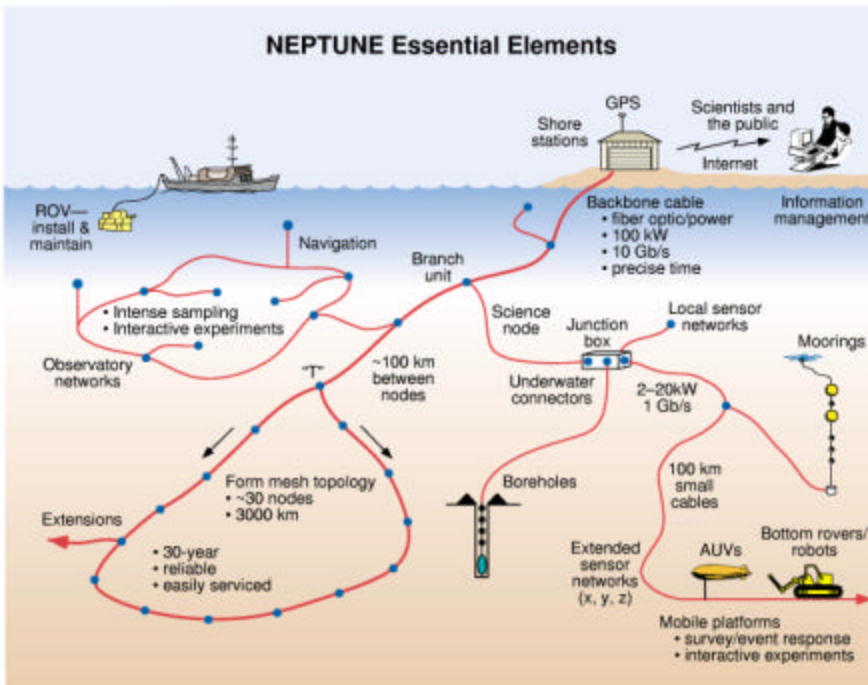


Figure showing preliminary location of NEPTUNE observatory nodes. The nodes are interconnected by cable with proposed landings in the inner harbour of Victoria, BC and Nedonna Beach, Oregon



Land based scientists and the public are linked in real time and interactively with sensors, sensor networks, and various mobile sensor platforms in, on, and above the seafloor. NEPTUNE's fiber-optic/power cable and associated technology provide the enabling network infrastructure (Graphic: Paul Zibton)

EXECUTIVE SUMMARY

NEPTUNE is a US/Canada initiative to create the world's first large-scale, long-term, deep-water observatory. The project involves the deployment of a network of instruments linked by optical fibres and a power grid on the Juan de Fuca (tectonic) plate off the coasts of British Columbia, Washington and Oregon. Approximately 21% of the Juan de Fuca plate is in Canada's Exclusive Economic Zone (EEZ), 47% in the US EEZ, and 32% in international waters.

Both the US and Canada have completed the first phase of NEPTUNE to study the feasibility and benefits of the project. This is the final report of the Canadian study group appointed by the Institute for Pacific Ocean Science & Technology (IPOST) to determine whether or not Canada should become a full partner in subsequent phases of the venture and if so, under what circumstances, terms and conditions.

The report concludes that NEPTUNE offers many opportunities for important and challenging scientific studies that would otherwise not be feasible. The scientific issues to be addressed can be grouped under the general headings of plate tectonics and earthquakes, climate change, and biodiversity and earth's major ecosystems. Further, NEPTUNE offers substantial industrial benefits both within the NEPTUNE project itself, and as a stepping-stone to participating in such projects around the world in the future. Furthermore, NEPTUNE can be a powerful force in increasing public awareness of the oceans and their importance to Canada.

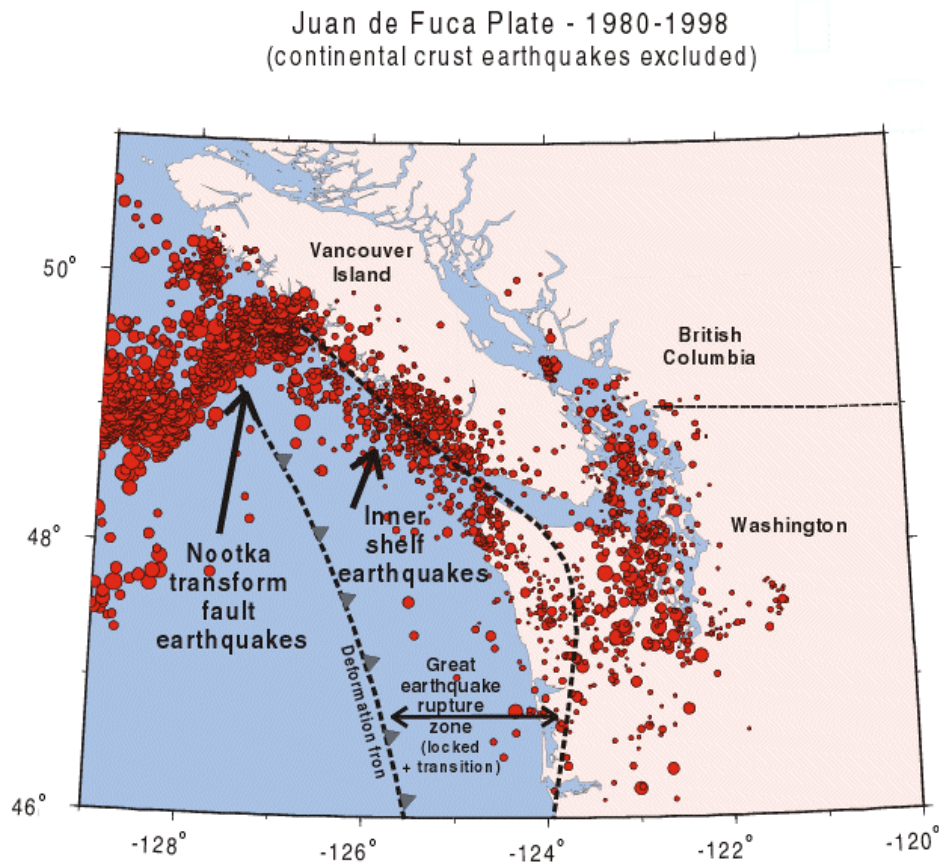
The benefits from Canadian participation can be summarised as:

- enhanced understanding of tectonic plate dynamics which are largely responsible both for the severe earthquake potential and for creating the mineral resources off Canada's west coast and elsewhere;
- better understanding of factors affecting the abundance of marine life in Canada's Pacific waters and their response to climate change;
- improved local models of ocean circulation affecting Canada;
- better information on the biodiversity of the deep sea floor that covers 60% of our planet, and an improved ability to assess the effects of human activities;
- opportunities to study the microbes of extreme environments as models for the origin of life and as potential biochemical products;
- educational and awareness opportunities created by a direct link to the ocean depths for educators and the general public (this opportunity could have particular impact if Canada proceeds with preliminary plans to establish a marine protected area at the Endeavour Ridge hot vent site);
- potentially important Victoria Ocean Observatory to familiarize British Columbians and visitors with ocean and seabed phenomena off our coast through live video feed and experiment exhibits, and to disseminate images and information worldwide;
- important industrial opportunities for BC and other Canadian companies in fields where they already have significant expertise;
- monitoring the state of methane gas hydrates off Canada's west coast. These hydrates are a huge potential source of both energy and greenhouse gases; and
- enhanced Canadian presence in the Canadian Exclusive Economic Zone (EEZ).

The Canadian NEPTUNE Management Board recommends that Canada partner with the US in the NEPTUNE project, and bear a 30 percent share of the total design, information and operating costs. The Canadian share of the development costs under this assumption is estimated to be approximately \$92

million¹ over a seven-year period beginning in January 2001. Of this total \$15.1 million would be devoted to engineering and scientific preparation in the first three years, with the remainder devoted to the installation of the network complete with scientific equipment. The Canadian proportional share of operating costs after NEPTUNE is up and running is estimated at \$4.5 million annually over the 30+ years projected lifetime of the observatory.

This cost structure is well within the norms for major international science projects in which Canada is a partner.



Earthquakes in the Juan de Fuca plate (1980 – 1998) beneath the north Cascadia margin (earthquakes in the continental crust have been excluded). The inner shelf earthquakes may mark the landward limit of the locked portion of the subduction thrust fault, but this hypothesis cannot be tested without data from seafloor seismic stations. The Nootka transform fault is a strong shaking source beneath the accretionary prism. (Graphic: R. Hyndman, Geol. Survey of Canada)

¹ All funds are in year 2000 Canadian dollars unless otherwise indicated.

1. INTRODUCTION

In 1998 research groups centred at the University of Washington and Woods Hole Oceanographic Institution received about US\$1 million² to study the feasibility of a network of unmanned observatories spanning the Juan de Fuca plate. This project was named NEPTUNE, for **N**orth **E**ast **P**acific **T**ime-series **U**ndersea **N**etworked **E**xperiments. The proposed network will provide the power and high-speed data transmission capability that will enable a host of important experiments to proceed, including a full array of water column and seabed sensors, acoustic equipment, high definition video cameras, flood lights and autonomous underwater vehicles running on rechargeable batteries.

Responding to the interest of Canadian scientists, the Institute for Pacific Ocean Science & Technology (IPOST) in Vancouver established a volunteer group which prepared a proposal³ that resulted in this study. The study was made possible by financial support from Fisheries and Oceans Canada (\$150,000), Natural Sciences and Engineering Research Council (\$50,000), Department of National Defence (\$25,000) and the Province of British Columbia (\$25,000). The study has been carried out under the direction of the Canadian NEPTUNE Management Board on behalf of IPOST.

2. BACKGROUND

Most experts date the real beginning of serious oceanographic studies to the commissioning of the Challenger expedition by the British Admiralty, at the urging of the Royal Society, in 1872. The epic four year voyage of HMS *Challenger*, and the subsequent painstaking cataloguing and preservation of the many life forms “dredged from the briny deep”, yielded results which are still relevant today – a testament both to the brilliance and hard work of the scientists of the day and to the slow progress made since then.

For most of the intervening years deep ocean studies have been carried out from a small number of specially equipped research vessels roaming the seven seas. Because of the vast area of the oceans, and the huge volume of water contained therein, there are only a few consistent time series of data that can be used to quantify changes in ocean conditions. There has been almost no capability for the continuous subsurface observatories needed to observe episodic events such as undersea earthquakes and eruptions, or the subsurface effects of violent storms.

In recent years observations provided by earth observing satellites and moored and drifting buoys have greatly enhanced our knowledge and understanding of the oceans. Satellites, however, provide us primarily with ocean surface information, while remote buoys are usually limited in power and communications capability. These limitations still seriously circumscribe our ability to observe deep ocean phenomena over a long time period, to accumulate comparative data over a wide area, and to respond to unusual events.

NEPTUNE is the first project to address these shortcomings in a substantial way. Rapid advances of optical fibre technology enable a new approach. Optical fibre communications systems, both on land and under the sea, are being deployed around the world at an unprecedented rate. It is

² The feasibility study was largely funded by the National Oceanographic Partnership Program (NOPP), a co-operative program financed by the National Oceanic and Atmospheric Administration, the National Science Foundation, and the Office of Naval Research. The study was also supported by the University of Washington, the Woods Hole Oceanographic Institution, the Jet Propulsion Laboratory (NASA) and the Pacific Marine Environmental Laboratory of NOAA. (Please see www.neptune.washington.edu)

³ *Project NEPTUNE, Live Link to the Deep Sea – An Important Opportunity for Canada*, June 1999, Institute for Pacific Ocean Science & Technology, Vancouver, BC. (Please see www.neptunecanada.com)

this global high volume telecommunications requirement which has driven down cable costs to the point where, for the first time ever, it is economically and technically feasible to install a large-scale ocean observatory system interconnected by cable and designed exclusively for scientific purposes⁴.

3. THE NEPTUNE PROJECT

NEPTUNE will be the first large-scale seabed and deep ocean observatory in the world. The proposed network will provide power for instrumentation (2-20 kW per observation node) and two-way data communications (at 2-10 Gbits/second). It will have approximately 3200 kms of cable and over 30 unmanned observing stations strategically positioned on the Juan de Fuca plate off the coasts of BC, Washington and Oregon, with cable landings in Victoria Harbour and at Nedonna Beach, Oregon. There will likely be future extensions further into the sub-arctic and sub-tropical gyres - areas of the Pacific Ocean with important influences on global weather and ocean food chains. This project is a huge step forward in mankind's laborious and belated attempts to better understand the 70% of our globe covered by oceans.

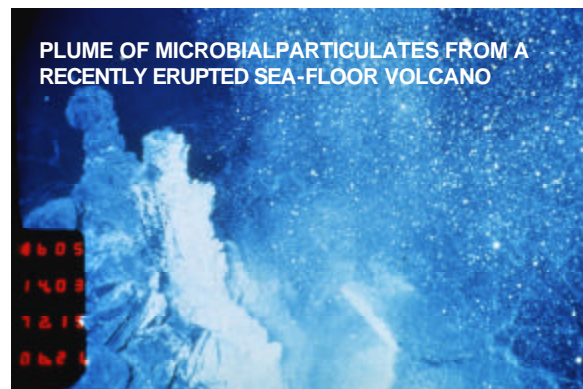
It is proposed that the observatory network be installed as a joint Canada-US undertaking. Although detailed boundaries have not yet been determined, approximately 47% of the Juan de Fuca plate lies in the US Exclusive Economic Zone (EEZ), about 21% in Canada's EEZ, and the remainder in international waters.

NEPTUNE embodies exciting and important science with substantial industrial opportunities and unequalled possibilities to engage students and the public at large in the exploration of the ocean and seabed. While many of the nodes will be placed in deep water, some will be located in shallow coastal waters. Canadian plans call for early "pilot" operations in the Georgia Basin.

Science

NEPTUNE is first and foremost a science project. An enthusiastic group of scientists from across Canada met in Victoria in March 2000 to consolidate their ideas for using NEPTUNE. As described in Appendix 1, Canadian scientists will use NEPTUNE to enhance our understanding of the geophysical processes which lead to earthquakes in British Columbia and elsewhere; provide us with information critical to predicting the effect of climate change on the marine ecosystem and fisheries of southern British Columbia; and greatly improve our ability to assess the effect of human activities on the biodiversity of the deep sea.

One example of particular interest is the opportunity to give worldwide, instantaneous access to Canada's proposed Endeavour Hot Vents Marine Protected Area, an area teeming with life and activity and the site of some of the highest temperature vents yet found. Hot vents are believed by some scientists to



(Graphic: Woods Hole Oceanographic Institution)

⁴ There are already several much smaller systems deployed off the coast of Japan, designed specifically to detect earthquakes and tsunamis.

have been crucial to the origins of life on Earth (and perhaps elsewhere). NASA's interest in Project NEPTUNE is driven in substantial measure by the possibility that life could be found at hot vents on Europa, the ice and (it is believed) ocean-covered satellite of Jupiter.

As a result of observations with NEPTUNE we will better understand the impact of climate change on ocean conditions, particularly the sub-surface northward transport of nutrients and larval animals along the eastern boundary of the ocean. This transport controls food supply in the marine ecosystem on the Canadian Pacific coast. NEPTUNE is ideally located for monitoring both long-term trends and year-to-year variations in this flow, providing the information needed to relate observed variations to variations in the large-scale wind field and other controlling mechanisms.

Canadian and US scientists propose many other experiments including measurements of the exchange of heat and gases between the ocean and the atmosphere (especially in high winds, where measurement is difficult and very important); measurement of carbon uptake and sequestration; observation of biodiversity on the seabed; study of the implications of seabed mining and of the effects of human pollution on the seabed; assessment of the energy resource potential (and global warming threat) of the very large deposits of methane gas hydrates on and in the seabed; and the recording, filming and categorization of the many strange life forms deep in and surrounding the hot vents.



*Picture of a deposit of gas hydrate on the ocean bottom
(Graphic: Scientific American)*

The many hundreds of experiments that will be undertaken using the observatory system will attract scientists from around the world. For example, Germany has already made a strong bid to lead a team of scientists examining the large deposits of methane gas hydrates off the coasts of Oregon and Washington. Similar reserves exist in large quantity offshore Vancouver Island.

Of particular interest in Canada is our plan to use the next three-year "system design" period to establish some low cost cable experiments in the shallow waters in Georgia Basin. These facilities, which have yet to be designed, will permit Canadian scientists to conduct valuable research while at the same time becoming familiar with the techniques and equipment appropriate to subsea cable based experiments (see Section 7.3 for more detail).

An extensive list of experiments proposed by Canadian scientists is contained in Appendix 1 to this report, while Appendix 7, Summary of the US Feasibility Study Report, provides a list of experiment topics discussed during the US Phase 1 study.

Industry

NEPTUNE will provide significant new opportunities for Canadian industry. It is the hope and expectation of the joint Canada-US NEPTUNE project team that our governments will encourage and provide for open bidding from Canadian and US companies on all major aspects of the infrastructure and/or those parts of the experimental apparatus connected to it which have commercial potential. Canadian expertise in sea floor mapping, undersea cable system engineering, remotely operated and autonomous undersea vehicles, data management and

instrumentation mean that Canada can field strong candidates for commercial benefits arising from the project. As the first project of such a scale in the world, suppliers to NEPTUNE are likely to be well placed to receive contracts related to future installations around the world.

This Canadian built remotely operated submersible is routinely in operation around the world in the service of science.



The insurance industry has a potential interest in NEPTUNE-related research that might lead to a better understanding of the potential for catastrophic losses in BC due to severe storms and earthquakes. There could be some interest from mining companies related to undersea mining research, but this has not yet been fully explored.

Secure in the knowledge of strong Canadian scientific interest, a series of consultations with industry representatives took place in early June. Meetings were held in Sidney, BC, St. John's, Halifax, Montreal and Vancouver with a more limited meeting in Toronto. The results of these meetings are reported in Appendix 2. In all, some 85 industrial representatives attended the NEPTUNE meetings. Letters from a number of these are included in Appendix 2.

Public Outreach and Education

NEPTUNE holds several immediately identifiable and attractive public awareness and educational benefits. The technology itself is "leading edge", and is being used to understand some of the most basic processes on our planet. People have proven to be very interested in these topics when they are communicated in an understandable way. Well positioned in the public eye, well communicated, and utilising the natural interest in the undersea world, (both geological and biological), the project can provide a very understandable focus for public audiences of many cultures and help to make Canada a world leader in science communication.



Hydrothermal vents found on the Juan de Fuca Ridge crest support an extraordinary ecosystem.

As one example, live video from the proposed Endeavour Marine Protected Area will be viewable over the Internet, potentially making this MPA one of the most accessible conservation areas in Canada, even though it is over 2km deep in the ocean, and over 200km from our nearest port!

The project will be set up from the beginning to provide the maximum public visibility and a wide array of public educational outputs. The overall focus on public communication and education as one of the major project activities begins with this proposal, will carry on through the study and the various proposal phases which will define NEPTUNE, and will remain a focus during implementation and operation.

Operators of museums, aquaria and science centres are well aware of the strong public appetite for scientific information related to oceans. We have been told that only medical scientific information commands greater public interest. Some compelling stories will arise from research using NEPTUNE, and some of these stories will come complete with fascinating video material. At the March 2000 science workshop in Victoria as well as in the deliberations of the Canadian NEPTUNE Management Board there was strong support for adopting the NASA practice of setting aside a defined amount (probably 1.5% to 2%) of the budget of every experiment to be devoted to public access and education. Please see Appendix 3 for further information.

The Victoria Ocean Observatory

While the original US-developed engineering plans proposed a Canadian cable landing at Port Alberni, it is now tentatively planned that the NEPTUNE Canadian cable landing will be in Victoria's inner harbour. By expanding the shore base to include facilities for public access, such a facility could serve as the anchor for the proposed Canadian NEPTUNE public access and education programs. Furthermore, the cost of back-hauling the data emerging from the cable to a major data network node for onward transmission to scientists and others will be reduced to almost negligible proportions if the cable landing is in Victoria.



An artists conception of the proposed Victoria Ocean Observatory which could provide school children and adults with front row access to the same video images and data received by the scientists using NEPTUNE for research purposes. Contributed by William De Hoog D'Ambrosio Architects.

While much study work remains to be done, a very preliminary examination suggests that the observatory could be located well within walking distance of the prime tourist attractions of downtown Victoria and could include:

- a theatre where viewers could observe samples of current activities on the network, as well as historical clips. Topics such as “Plate Tectonics and Earthquakes”, “Life in the Hot Vents”, “Biodiversity in the Ocean” and “Ocean Currents and their Effects on Ocean Life” could be copiously illustrated with video and data collected by the NEPTUNE network;
- viewing stations for observation of the cable, its powering and protection circuitry, and the data archiving and library access system; and
- displays of the major experiments currently attached to the NEPTUNE array, combined with an explanation of their objectives.

This observatory could also serve as a packaging centre for dissemination of program material in a variety of formats (including streaming video) which could be viewed at science centres and aquaria across Canada and around the world.

A special group under the Chairmanship of Mr. Ian Stewart, a regent and past Board Chairman of the University of Victoria, has been established to pursue the practicalities of building such a facility. It is expected that its findings will be available in February 2001.

Emergency Measures

The Juan de Fuca Plate is sliding under the North American Plate at a rate of about 4.2 cm per year. This subduction process, combined with some lateral slippage along fault lines, gives rise to periodic earthquakes along the Pacific Coast as well as inland and under the sea. While the origins of our earthquake hazard are well understood in principle, we are a very long way from having enough detailed knowledge to be able to predict periods of increased or decreased risk of earthquakes.

Preliminary data from US Navy hydrophones located off the coasts of Washington, Oregon and California give us confidence that detailed measurements of Juan de Fuca plate behaviour over time will yield a trove of information resulting in improved estimates of earthquake effects and risks. This data is important to engineers and others whose task is to seek means of mitigating the harm done by earthquakes. While the scientific experts consider the chances of developing a predictive capability a 'long shot' at best, the Kobe⁵ experience suggests that the payoff from a better understanding of the likely timing and severity of earthquakes and tsunamis could be very substantial.

4. WHY SHOULD CANADA PARTICIPATE?

We believe that the scientific returns alone are ample justification for Canadian participation, though scientific returns are by no means the only benefits. The benefits from Canadian participation can be summarised as:

- enhanced understanding of tectonic plate dynamics which are largely responsible both for the severe earthquake potential and for creating the mineral resources off Canada's west coast and elsewhere;
- better understanding of factors affecting the abundance of marine life in Canada's Pacific waters and their response to climate change;
- improved local models of ocean circulation affecting Canada;
- better information on the biodiversity of the deep sea floor that covers 60% of our planet, and an improved ability to assess the effects of human activities;
- opportunities to study the microbes of extreme environments as models for the origin of life and as potential biochemical products;
- educational and awareness opportunities created by a direct link to the ocean depths for educators and the general public (this opportunity could have particular impact if Canada proceeds with preliminary plans to establish a marine protected area at the Endeavour Ridge hot vent site);
- potentially important Victoria Ocean Observatory to familiarize British Columbians and visitors with ocean and seabed phenomena off our coast through live video feed and experiment exhibits and to disseminate images and information worldwide;
- important industrial opportunities for BC and other Canadian companies in fields where they already have significant expertise;

⁵ On January 17, 1995 a force 7.2 earthquake struck Kobe, Japan, a city of 1.5 million inhabitants. 5,500 people died, 35,000 were injured, 180,000 buildings were damaged or destroyed. Damage was estimated to be between US\$97Billion and US\$147Billion. Prior to 1995 it had been assumed that Kobe was at greater risk from tsunamis than from earthquakes.

- monitoring the state of methane gas hydrates off Canada's west coast. These hydrates are a huge potential source of both energy and greenhouse gases; and
- enhanced Canadian presence in the Canadian Exclusive Economic Zone (EEZ).

Canada provides substantial support for other international scientific projects of comparable size on the basis of similar considerations. A list compiled in January 2000 by the Innovation Policy Branch of Industry Canada⁶ lists some 25 projects, not all of which are currently funded. The larger of the currently funded projects can be grouped as follows.

Description	Canadian Contribution (\$million per annum)
Nuclear and Particle Physics projects	
European Centre for Nuclear Physics (funded through TRIUMF)	\$ 6.0
Sudbury Neutrino Observatory (SNO) \$75 million capital cost	\$ 10.0
Various High Energy Physics (through NSERC)	\$ 2.8
Space Science projects	
Various Space Science projects (through NSERC)	\$ 0.9
European Space Agency contribution	\$ 17.3
Space Shuttle (estimates not provided)	
Astronomy projects	
Canada-France-Hawaii Telescope	\$ 4.4
Gemini Telescopes	\$ 3.0
James Clerk Maxwell Telescope	\$ 1.0
ALMA Radio Telescope (proposed, not yet funded)	\$ 4.0
Next Generation Space Telescope (proposed, not yet funded)	\$ 7.6
Genetics projects	
Human Genome Project	\$ 5.0
Ocean and Seabed projects	
Ocean Drilling Program	\$1.3
NEPTUNE (proposed, not yet funded)	
First 7 years average (design and construction – total \$92.1 million)	\$13.2
Subsequent years (operating)	\$ 4.5

Missing from the above list because they are primarily national rather than international projects are the recently approved Saskatchewan Light Source, whose capital cost is \$173.5 million, and TRIUMF activities other than noted in the table above. The current TRIUMF budget is approximately \$40 million p.a.

The reason for showing this comparative data is to provide a rough feel for Canada's involvement in international science generally. It is surprisingly difficult to find comprehensive, accurate data in this field, but we think that the figures above provide a reasonable overview. We also think

⁶ This data is summarized from a five page memorandum entitled "Federally Funded Participation in International Research Projects and Programs", prepared in January 2000. We are grateful to Stuart Wilson, Chief, Science Policy at Industry Canada for making this information available. In Mr. Wilson's view, "The list should not be considered exhaustive, but does provide a fair picture of Canada's major federally supported international research activity." (private correspondence)

that a fair inference can be drawn that providing funding for NEPTUNE will help provide a healthier balance to the overall international collaboration roster of activities.

Another measure of the value of NEPTUNE is provided by comparison with the cost of a major offshore research vessel. A modern vessel similar to the US Class 1 research ships R/V *Thomas G. Thompson*, R/V *Atlantis* or R/V *Ronald H. Brown* provides 30 berths for scientists and will operate at sea for between 250 and 300 days out of the year. It will cost approximately \$90M to construct, without ice strengthening. Such a vessel will have a useful life of 30 to 40 years, but will require a mid-life refit costing perhaps \$20M. It will cost \$5M to \$9M per year to operate, plus another \$3M to \$5M if a submersible is required. A research vessel can go anywhere in the world's oceans, slowly, but can make observations in only one place at a time. In extreme weather, observing capabilities are limited. Only those lucky enough to be on board have immediate access to the information collected. The proposed Canadian share of the construction and operating costs of NEPTUNE are comparable to the construction and operation of one offshore research vessel. In return an unlimited number of scientists and students have immediate access to information from a number of locations in any weather. Observing systems can be controlled at any time.

In contrast to many other science projects, NEPTUNE will support Canadian scientists in a broad range of disciplines, including geophysics, geology, geochemistry, marine biology, ecology, oceanography, climate studies, fisheries science, robotics, electrical engineering and computer science. Results from NEPTUNE will have an immediate impact on issues of direct, practical Canadian concern.

5. OPTIONS FOR CANADIAN PARTICIPATION

The Canadian NEPTUNE Management Board considered four options for Canadian participation.

1. We could become a full partner with the US, paying a proportional fair share of both the infrastructure and the experimental costs.
2. We could participate as experimenters only, clients of NEPTUNE. Under this option we would be expected to pay a share of the experiments in which we take part, possibly with an additional overhead allocation. As a variant, in return for giving the US permission to operate the network in our EEZ, we might demand and receive some rights of access to experiments on the network without cost.
3. We could decline to participate but permit the US to install and operate the NEPTUNE network as planned.
4. We could decline to participate and limit any US observatories to areas outside our EEZ.

The Canadian NEPTUNE Management Board recommends Option 1 for the following reasons.

1. There is a strong scientific justification for Canadian involvement in NEPTUNE.
2. A partnership position better reflects Canadian sovereignty over a significant portion of the region covered by the array, and offers more control over the acquisition and distribution of information from the Canadian EEZ.
3. A full partner can influence the design of the network to ensure that it meets Canadian needs.
4. As a partner Canada is in a better position to capture industrial benefits, both immediately and in future markets.

There is no easy way to determine what a Canadian “fair share” of the total NEPTUNE cost should be. A figure of 30% reflects, in approximate terms, both the proportion of the Juan de Fuca plate which lies in Canadian waters (40,000 square kilometres) relative to that in US waters (90,000 square kilometres: the rest is in international waters) and the relative proportion of Canadian (as opposed to US) scientists who will likely make use of the observatory. A 30% commitment represents the minimum requirement to have the influence on policy and design decisions needed to maximize Canada’s scientific and industrial benefits. On these grounds, 30% has been used as a working figure by the Canadian NEPTUNE Management Board.

6. SCHEDULE AND FUNDING IMPLICATIONS

NEPTUNE is essentially a science undertaking, with close parallels to early space probes. As was the case in the early days of space exploration, governments have to take the funding initiative. Important as a better understanding of the seabed and the deep oceans is to society at large, there are no known industry segments which might reasonably be expected to make major financial contributions to such an undertaking at this early stage. Private sector funding will be sought from the outset, and some will be found, perhaps, for specific aspects of the study phase. Substantive support is more likely, however, to come in later as the project matures and the commercial benefits become more apparent and imminent.

We have set out estimated expenditures in Table 1 for each phase of NEPTUNE. These estimates are primarily drawn from the US NEPTUNE Feasibility Study (see Appendix 9), as reviewed by a Canadian committee of experts (see Appendix 4). As previously discussed, the Canadian share has been budgeted at roughly 30% of the total.

The US long-range budget includes US\$120 million for seafloor observatories, starting in 2003. The US NEPTUNE office is preparing a proposal for infrastructure funding from this source.

Table 1: Estimates Of Projected Total And Canadian Expenditures To Implement NEPTUNE			
In Year 2000 Canadian Dollars			
Activity	Timing	Estimated total cost	Recommended Canadian share
Phase 1: Study Assess scientific benefits and technical feasibility, estimate costs.	1999-2000 Complete	\$1.75M (actual)	\$250,000 (actual)
Phase 2: Development Science and engineering design, define technical requirements, prototypes, carry out pilot observatory project, complete specifications and bid packages.	Start 2001 Complete 2004	Backbone: \$19.3M Science: sensor development, pilot observatories \$31.5 M	Backbone and science: \$6.1M Pilot observatory network: \$9.0M
Phase 3: Installation Construct and deploy the NEPTUNE backbone infrastructure and initial observing systems	Start 2003 Complete 2007	Backbone: \$134M Science: \$124M	Backbone: \$40M Science: \$37M
Phase 4: Operation Operate and manage the system, install and service observing systems, manage data, public access and education.	Start 2004 For at least 30 years	\$15 M annually	\$4.5 M annually

One possible scenario for year-by-year expenditures is shown in Table 2, but these figures are hypothetical as they depend on unknowns in engineering and funding.

Year	Canada	US and other partners	Total
2001	Ph 2 \$ 4.0	Ph 2 \$10.0	Ph 2 \$ 14.0
2002	Ph 2 \$ 5.0	Ph 2 \$11.0	Ph 2 \$ 16.0
2003	Ph 2 \$ 6.1	Ph 2 \$11.0	Ph 2 \$ 17.1
	Ph 3 \$ 7.0	Ph 3 \$17.0	Ph 3 \$ 24.0
2004	Ph 2 \$ 4.0	Ph 2 \$ 4.0	Ph 2 \$ 4.0
	Ph 3 \$30.0	Ph 3 \$70.0	Ph 3 \$100.0
2005	Ph 3 \$10.0	Ph 3 \$23.3	Ph 3 \$ 33.3
	Ph 4 \$ 4.5	Ph 4 \$10.5	Ph 4 \$ 15.0
2006	Ph 3 \$30.0	Ph 3 \$70.0	Ph 3 \$100.0
	Ph 4 \$ 4.5	Ph 4 \$10.5	Ph 4 \$ 15.0
2007 and after	Ph 4 \$ 4.5 Annually	Ph 4 \$10.5 Annually	Ph 4 \$ 15.0 Annually

Three government departments with a direct interest in the oceans and sea floor, namely Fisheries and Oceans Canada, Natural Resources Canada and the Department of National Defence, are currently proposing a program called “SEAMAP”, which would involve the mapping of Canada’s entire Exclusive Economic Zone. Should this happen, the mapping of the Canadian NEPTUNE area under SEAMAP would constitute an important in kind contribution to NEPTUNE. The costs shown in Table 1 and 2 do not include mapping, so approval for SEAMAP would not reduce the amounts needed. Should SEAMAP not proceed, it is estimated that an additional \$2 million will be required.

7. PHASE 2 ACTIVITY PLAN

If Canada becomes a full partner with the United States in Project NEPTUNE, then Canada will actively participate in all aspects of planning and design of the NEPTUNE system, and will install and operate a pilot observatory program for developing and testing observing systems, data management, communication and education interfaces.

It has been agreed with the US partners that Canada should assume prime responsibility for at least one of the major engineering tasks identified during the systems study.

Preliminary discussions with scientists and officials from the National Research Council of Canada have convinced us that the personnel at the Canadian Astronomy Data Centre (CADC), located at NRC’s Dominion Astrophysical Observatory just outside Victoria, are well qualified to lead a study of the information management and archiving requirements of NEPTUNE. Such a study would be a natural extension of their current international activities related to the archiving of data from the Hubble, Gemini and other telescopes. We believe that their participation with NEPTUNE would likely be beneficial to both the oceanographic and the astronomical communities.

Importantly, in Phase 2 NEPTUNE Canada will establish one or more pilot, interactive observatory stations for the development of the scientific, engineering and public education

components. These pilot sites will be of a simple design and employ commercially available technology to provide basic power and communications for operational testing of observing systems suitable for eventual use with NEPTUNE. They will permit Canadian and US scientists to acquire very necessary training and experience in working with continuous, real-time data streams from ocean observatories. Seafloor installation procedures will be tested and improved. Real observations will also give scientists and marine educators something to work with in learning how to create interactive outreach tools.

The US team has welcomed Canada as a full partner in the design and construction. Canada is presently participating in Phase 2 planning. The organizational structure for the design and implementation of the NEPTUNE observatory was agreed upon at an international meeting held at Emerald Lake, BC in late September 2000.

Overall management will be the responsibility of an Executive Committee, initially comprising six members, but which is designed to grow to a maximum size of ten. The initial six members will be one representative each from the University of Washington, Woods Hole Oceanographic Institution, the Monterey Bay Aquarium Research Institute and the Jet Propulsion Laboratory of NASA, plus two representatives from Canada. It is planned that the Chairpersons of the three principal NEPTUNE committees, i.e., Science, Infrastructure (i.e., Engineering) and Outreach will also join the Executive Committee. An additional seat on the Executive Committee has been reserved for a scientist not affiliated with any of the founding institutions. The NEPTUNE project office will be located at the University of Washington. It is envisaged that IPOST will host the Canadian project office.

It is also planned that an independent oversight committee comprised of distinguished scientists and engineers will be established. The oversight Committee's job will be to act as a monitor, evaluator and critic of NEPTUNE plans and priorities.

It is estimated that the Canadian share of NEPTUNE Phase 2 will cost \$15.1 million over a three year period. Phase 2 activities are broken out in Table 3 and described in greater detail below. Unless otherwise indicated all financial information is in Year 2000 Canadian dollars and covers approximately three years, starting in January 2001.

7.1. Design and Engineering of the NEPTUNE System (\$2,600,000)

The engineering of the NEPTUNE observatory network itself involves the following major activities:

- overall system design and engineering;
- cable route and node location planning;
- communications network design;
- power and protection system design;
- data management and archiving specification and design;
- robotic support systems specification, design and test; and
- component and system testing.

Phase 2 funding in the US is developing as a series of smaller funding and financing initiatives through a variety of sources. There are strong indications of the availability of funding for Phase 3 (System Installation). It has been assumed that two activities (sea floor mapping and robotic support systems design and test) will be funded independently of the project.

Four US organizations (the University of Washington (UW); Woods Hole Oceanographic Institution (WHOI); NASA's Jet Propulsion Laboratory (JPL) and the Monterey Bay Aquarium Research Institute (MBARI) have joined together to undertake Phase 2 engineering. These organisations are currently performing the following primary roles:

UW	NEPTUNE headquarters, overall coordination and management
WHOI	Communications network design and engineering, robotics
MBARI	Deep water test facility, robotics
JPL	Network powering and protection

The WHOI data network design and engineering activity is fully funded at a level of US\$2 million, primarily by the National Science Foundation (NSF). MBARI has tentative approval from the David Packard Foundation for a deep-water cable facility in Monterey Bay that will serve as a test bed for NEPTUNE nodes and their associated experimental apparatus. The cost of this facility was initially estimated at less than US\$5 million, but recent estimates are higher. The University of Washington and the Jet Propulsion Laboratory have submitted a proposal to the NSF for funding of the network power and protection system design. Whether the US Office of Naval Research will fund the seabed mapping required by NEPTUNE (estimated at US\$5 million) is not yet known.

Canada will take primary responsibility for the design and engineering tasks related to the cable landing and shore site in Canada. Canadian NEPTUNE planning has assumed that this landing will be in Victoria, BC rather than Port Alberni as originally planned. This would offer many advantages, including a direct connection to the CANARIE network and access to a significant audience for a major interpretative centre. A detailed study is required for design and costing purposes.

It would also be appropriate for Canada to take responsibility for at least one of the major tasks associated with observatory engineering, in addition to the participation of Canadians on the teams for the other tasks. One obvious candidate is data archiving and management. Canada also has strengths in the areas of robotics design and testing and data network design.

At the International NEPTUNE meeting at Emerald Lake, BC in late September, 2000 it was agreed that the Canadian Astronomy Data Centre group at NRC's Hertzburg Institute in Victoria would be an ideal candidate to lead the engineering and design studies for data management and archiving. Our understanding is that NRC would be very interested in carrying out this task provided the necessary funding can be arranged. It is planned that the design and engineering activities associated with this work by NRC would be funded by NEPTUNE and would be a key component of the overall Canadian design and engineering activity.

The design and engineering components requiring funding will include:

- a leader/coordinator for Canadian activities;
- expenses for Canadian experts participating in various aspects of the system design and engineering; and
- support for contracted engineering and technical studies.

The US feasibility study estimates a total cost of \$8.6 Million (US\$5.7 million) over three years for infrastructure system design. Until such time as the precise nature of Canadian participation in the design and engineering activity is known, we have estimated the Canadian share at 30% of the US total.

TABLE 3: NEPTUNE Phase 2 Activity Plan		Estimated Cost over three years
1.	<u>Design and Engineering of the NEPTUNE System</u> Partner in the design and engineering of the NEPTUNE network, power and data management systems, including an engineering study of using Victoria as the Canadian landfall.	\$2,600,000
2.	<u>Planning of Initial Science Experiments</u> Participation of Canadian scientists in the working groups and committees planning the initial science experiments and developing the technical requirements to support those experiments.	\$960,000
3.	<u>Pilot Observatory Program</u> Establish one or more observing systems in easily accessible inshore waters to permit development and testing of observing systems; provide funding for Canadian science and industry to develop and test systems at these or US sites.	\$9,000,000
4.	<u>Seafloor Mapping</u> Through the SEAMAP program, map the NEPTUNE route and potential node and observatory sites in the Canadian EEZ, including geological and biological sampling needed to select sites. (Estimated cost \$2M)	Funded separately
5.	<u>Public Outreach and Education</u> Provide information on NEPTUNE; determine Canadian needs for information from NEPTUNE and support the development of Canadian educational activities using NEPTUNE.	\$435,000
6.	<u>Environmental Issues and Permitting</u> Address environmental issues and obtain necessary permits for the portion of NEPTUNE in Canadian waters.	\$75,000
7.	<u>Project Management and Co-ordination</u> Participate as major player in the management of the international NEPTUNE project; maintain a Canadian NEPTUNE office to support specifically Canadian activities.	\$2,030,000
Total Canadian Phase 2 costs over 3 years		\$15,100,000

7.2. Planning of Initial Science Experiments (\$960,000)

The US Feasibility Study Report sees this as involving three activities at an estimated three-year cost of \$4.3 Million (US\$2.8 million):

- establishment of science working groups to define the community experiments and information management requirements, pursue the development of experiments, and focus attention on needed new technologies;
- design and prototype testing of community experiments on a schedule that will assure readiness for deployment; and
- development of a strategy to make the NEPTUNE system attractive and user friendly for individual scientists.

Strong Canadian participation in this activity is essential if Canada and Canadian scientists are to derive appropriate long-term benefit.

One clear requirement is for Canadian scientists to be able to participate energetically in the various science working groups, and to be able to host working group meetings in Canada. Assuming that there will be approximately 30 meetings/year (seven working groups each meeting four times) with an average of two Canadians participating, a travel subsidy budget of about \$120,000 will be required annually. An additional \$40,000 will be required to allow Canada to host 30% of these meetings. Over three years this will total \$480,000.

There is also a clear requirement for Canadian scientific leadership to undertake activities such as working with Canadian scientists to plan and negotiate for approval of proposed experiments; soliciting international participation in Canadian-led experiments and vice-versa; working with US associates on the specification and location of network nodes; promoting the participation of Canadian scientists in public access and educational activities; promoting the participation of Canadian industry in the provision of equipment and services where appropriate; assisting with the publicity and fund raising activities of the project; ensuring that critical engineering decisions are consistent with Canadian science needs; and attending organizational meetings in Canada and the US.

It is proposed that two co-leaders be appointed to provide suitable leadership to the Canadian NEPTUNE Project. Doing this will permit geographical and disciplinary diversity and make the task attractive to leading scientists by reducing the burden on any single individual. Canadian interests in the NEPTUNE science program span a very broad range of disciplines, which would make it difficult for one individual to represent the whole community. If a single individual were sought to carry the whole burden, the scope of the necessary activities would demand an excessive professional sacrifice, making the job less attractive to the active scientists who are needed. Assuming that these leaders will be academics, approximately \$45,000 annually will be required for each of them to offset the loss of time to their universities, nominally by hiring additional staff for teaching and research. In addition each will require at least \$35,000 annually for travel and administrative support, bringing the estimated cost for this component to \$480,000 over three years.

The total estimated cost for Canadian participation in Phase 2 planning and design of initial community experiments is \$960,000 over three years.

7.3. Phase 2 Pilot Interactive Observatory Program (\$9,000,000)

Development of the skills needed to use remotely operated interactive observing systems and real time data effectively is a critical part of the overall NEPTUNE program. This is a totally new way of doing ocean science, and scientists will take some time to learn how to use the new tools. Development and testing of the interactive sensors and observing systems, which will generate the data that will ultimately justify NEPTUNE, are also critical to the success of the project.

In Phase 2 NEPTUNE Canada will establish one or more pilot, interactive observatory stations for the development of the scientific, engineering and public education components. These pilot sites will be of a simple design and employ commercially available technology to provide power and communications for operational testing of observing systems suitable for eventual use with NEPTUNE. They will permit scientists to acquire very necessary training and experience in working with continuous, real-time data streams from ocean observatories. Seafloor installation procedures will be tested and improved. Real observations will also give scientists and marine educators something to work with in learning how to create interactive outreach tools.

One or more easily accessible near-shore pilot sites will be linked by small optical fibre and/or electrical cables to nearby research institutions, which will in turn link to the Internet. In terms of the overall NEPTUNE architecture, the research institutions will act as the science interface, providing ports for connection with the underwater sensor networks. The 'backbone' will be provided by the Internet. Data will be managed as if they were NEPTUNE 'community experiment' data. A pilot data centre will be established to make the data widely available. One model for such a centre is the Canadian Astronomy Data Centre.

Sites and observing systems will be selected for their scientific interest and relevance to NEPTUNE scientific objectives, as well as their accessibility and proximity to research institutions. A number of candidate pilot observatories have already been suggested:

- sediment dynamics and slope stability on the Fraser River delta;
- nutrient flux measurements, including profiling chemical sensor packages in Juan de Fuca Strait;
- whale and fish tracking in Haro Strait;
- rocky substrate ecosystem dynamics at Race Rocks; and
- monitoring seismic activity in the Strait of Georgia;

Other suggestions can be expected as more scientists become aware of the possibilities. Final selection of near shore observatory locations will be made through an objective process considering costs, scientific and technological returns and potential for education and outreach.

The infrastructure of shore stations, some parts of the cables and data management and distribution will be available to both Canadian and US scientists. By providing an early, accessible way of testing sensors and observing systems the Canadian infrastructure will complement the US deep water test site proposed for Monterey Canyon, and allow the deep water site to focus on testing the NEPTUNE backbone, backbone interface and science interface. A budget of \$1.0 million annually over three years is estimated to be the minimum which will permit installation, operation and servicing of a minimum infrastructure, including vessel support, a project manager and data management.

The NEPTUNE Canada Phase 2 plan includes an additional \$2.0 million annually to support the development and testing of the sensors, observing systems and other NEPTUNE components by Canadian scientists and Canadian industry. Following selection of pilot observatory sites, proposals for instrument design and testing, data management, outreach tools and seafloor engineering tests will be reviewed by a scientific panel. Individual proposals for the design, construction and testing of individual instruments are expected to be in the \$100,000 to \$300,000 range, allowing 4-10 projects per year to be funded. This program, the NEPTUNE Science and Industry Program (NSIP), will permit Canadian industry to make “unsolicited proposals” to scientists and engineers working on the NEPTUNE program to develop and provide instrumentation or equipment for use with NEPTUNE. Testing could use a NEPTUNE Canada pilot observatory, the US NEPTUNE test facility or another site such as NeMONet (see below). Individual proposals will require the backing of at least one scientific or engineering group (who would use the resulting product), and an impartial expert board will adjudicate applications.

The overall three-year budget for the NEPTUNE Canada Pilot Observatory Program is \$9.0 million. It is assumed that US scientists will secure their own funding for development of sensor and observing systems. The funding required for this is estimated in the US Feasibility Study Report at \$22.5 million (US\$15 million). The cost of the Canadian Pilot Observatory thus represents slightly less than 30% of the combined total.

The addition of a NEPTUNE Canada module to the deep-water NeMONet observatory operated by the US National Oceanic and Atmospheric Administration (NOAA) is also a possibility. NeMONet, established in 1999, is located at a hydrothermal vent site on Axial Volcano on the Juan de Fuca Ridge. Seafloor instruments are linked acoustically to a surface buoy that communicates via satellite to land stations. Near-real-time image and data transmission was demonstrated in 1999 and NeMONet 2000 has limited interactive instrument control capability.

The pilot stations and the information and experience acquired there will remain as a permanent legacy for Canadian scientists, engineers and the general public. Marine science in the 21st century will inevitably see increasing demand for real-time information. Phase 2 will provide an early opportunity for training young Canadian marine scientists and engineers in conducting research using remote instrument observatories in the ocean.

7.4. Seafloor Mapping (Independently Funded)

Planning for the placement of nodes and interconnecting cable routes will require detailed maps including biological and geological information. The US Feasibility Study Report estimated that this will cost approximately \$7.5 million (\$5 million US). This cost was not included in the overall cost of NEPTUNE as a proposed larger US Office of Naval Research project to map the global seabed called GOMAP was expected to provide the necessary maps. At the time of publication it is not known whether or not this project will be approved.

Whatever the outcome in the US, it would be appropriate for Canada to assume responsibility for the mapping of her own EEZ. A separate Canadian initiative called SEAMAP is proposing to map the entire Canadian EEZ. SEAMAP could provide the maps needed for NEPTUNE provided that mapping of the Canadian portion of the Juan de Fuca plate is one of the first tasks undertaken by SEAMAP. Mapping of the Canadian portion of the NEPTUNE area, including the necessary biological and geological ground truthing of the seafloor, is estimated to cost approximately \$2 million. The Canadian NEPTUNE Phase 2 budget is based on the assumption that this will be included as a part of the SEAMAP overall budget.

7.5. Public Outreach And Education (\$435,000)

NEPTUNE will connect on several levels with the public as well as with special audiences such as students. Experience so far indicates that the public finds the very concept of NEPTUNE fascinating.

Both Canadian and US Phase 2 plans place great emphasis on ensuring that there is a strong and well-integrated education and outreach program associated with NEPTUNE. Although much can be done in common, Canadian audiences have sufficiently different interests from those in the US to require some special attention.

Canadian educators will be able to participate with their US counterparts in planning activities related to the exploitation of NEPTUNE in the curriculum, particularly K-12. The US Feasibility Study Report recommends a “national program” for education and outreach, with two planning workshops scheduled during Phase 2. We agree with this approach in general, but would recommend that the workshops be held jointly with Canadian as well as US participation. We propose preparing for the workshops by conducting consultations with the K-12 and post-secondary communities in BC during the first year to ascertain potential uses for NEPTUNE information and output.

The Canadian NEPTUNE program also requires an effective communications program to make the broader public aware of NEPTUNE, allow them to follow the development and implementation of the project and permit NEPTUNE to provide interpretative material as observations and data become available.

The Canadian communication and education strategy during Phase 2 thus involves three major activities:

- providing a steady flow of information to ensure that various audiences and user groups are knowledgeable about the development of NEPTUNE and the Canadian program;
- identifying Canadian audiences and user groups (other than researchers) for outputs from NEPTUNE operations, determining what information they need, and identifying the needs of potential intermediaries in information delivery; and
- co-ordinating the participation of Canadian educators in curriculum-related NEPTUNE activities.

The first two activities will be the job of a full-time Communications Co-ordinator, working with the Canadian NEPTUNE Management Board and the rest of the NEPTUNE Canada Phase 2 team. The estimated cost for these activities is \$300,000 over three years, including salary and the cost of communications materials and services. Co-ordination of the interface with educators will be achieved through an expert seconded from one of several public education institutions on a part time basis at an estimated three-year cost of \$75,000. An additional \$60,000 will be needed for subsidizing travel attendance by Canadian educators to meetings and for directed contracts where needed. The total cost is estimated at \$435,000.

The pilot observatory project described in Section 7.3 above will also include demonstration, education and outreach activities. It is proposed to establish a site in downtown Victoria for the display and interpretation of information from NEPTUNE. This latter initiative is still speculative, and no separate budget has been prepared for it.

7.6. Environmental Issues and Permitting (\$75,000)

All ocean cable systems now require permits to ensure that environmental damage is kept to acceptable levels. Permits related to the portion of the system in Canadian waters, including the Canadian shore landing, will be the responsibility of the Canadian project team. This will require interaction with the appropriate agencies as well as consultations with the public and interested environmental groups. We believe that NEPTUNE's scientific activities are largely pro-environment and will be supported by most environmental groups, but this belief must be confirmed. The cost of some of this work has been subsumed as a part of general management, but specialized consulting help will be needed. The cost over three years is estimated at \$75,000.

7.7. Project Management and Coordination (\$2,030,000)

The overall NEPTUNE plan, which we strongly endorse, is for the program to be managed from an office on the campus of the University of Washington. However, the engineering and scientific tasks will be carried out by individuals located in many different institutions, some of which will be in Canada. A Canadian NEPTUNE office will be required to look after national interests, ensure that Canadian responsibilities are efficiently contracted and executed, and liaise with Canadian industry, Canadian scientists, and the Canadian educational community. Experience with other international collaborations such as astronomical observatories has shown the importance of this.

The Canadian project office will be staffed by a full time Executive Director, supported by an assistant. The same office will house the Communications Co-ordinator, the Industry Co-ordinator, the pilot observatory Project Manager and other support staff as required. The cost of

the Canadian project office is estimated at \$530,000 annually. This office could be co-located with IPOST.

The government departments which have funded IPOST from the outset have stated their expectation that IPOST will become self-sustainable through the successful development and implementation of projects. Under this plan, self-sustainability is to be achieved by IPOST receiving fees as a percentage of project budgets.

The proposed IPOST management fee of 3% reflects the entrepreneurial and professional work that IPOST has performed in developing NEPTUNE Canada and bringing it to this stage, as well as IPOST's ongoing responsibility for project design and implementation. The development of NEPTUNE Canada has been a lengthy and complex process involving not only the paid time of IPOST professionals and contractors, but also substantial non-reimbursed work by IPOST's Executive Director and staff, some of its Directors, and outside colleagues and scientists from across Canada.

The long list of personal contacts combined with the wide-ranging skill set of IPOST members (including the members of the Science and Industry Advisory Committee) have been invaluable during the NEPTUNE study phase. They are expected to be equally useful during the upcoming Engineering and Pilot Project phases.

For these reasons, we have budgeted for IPOST to receive a service fee based on 3% of project revenues in any given year during Phase 2. This provision will cost the project approximately \$147,000 per year, a total of \$440,000.

8. RECOMMENDATIONS

The Canadian NEPTUNE Management Board, a pan-Canadian committee of scientists, industry representatives and government officials recommends that the Governments of Canada and British Columbia agree in principle that Canada become a full partner with the US in the NEPTUNE project and that Canada undertake to fund approximately 30% of the total project costs.

The Board recommends that the Governments of Canada and British Columbia provide funding of \$15.1 million over a three year period commencing in January 2001 for Canada's portion of NEPTUNE Phase 2, to permit us to work with our American colleagues in the detailed planning and engineering of the project and in the launching of the Canadian scientific program. The funding to be required for Phase 3, estimated at \$77 million, will be finalized during Phase 2.

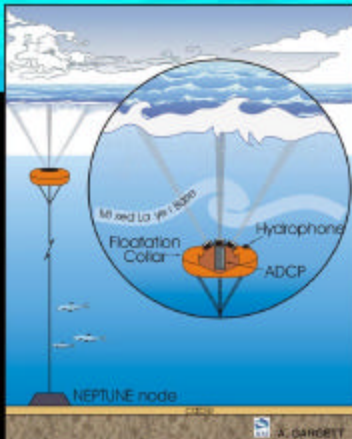
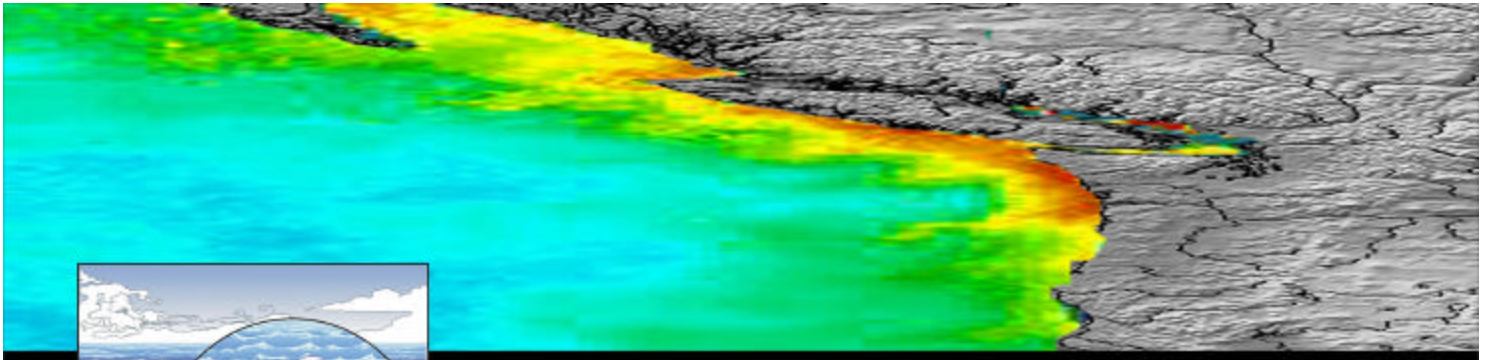
The Institute for Pacific Ocean Science & Technology (IPOST) is prepared to continue to provide day-to-day leadership in the Canadian NEPTUNE program, including co-ordination and co-operation with NEPTUNE management in the United States. We recommend that the interested government departments and agencies work with IPOST to ensure that Canadian participation in NEPTUNE is appropriately managed throughout the life of the system.

“Even with many research ships operating year round, the information we gather provides only a glimpse of the ocean's physical, chemical and biological processes. Because phenomena are highly dynamic, fully understanding them would require continuous, simultaneous measurements spanning weeks or years and thousands of kilometers. Instead we have only spot measurements, sparsely distributed around the globe. The result is that we know less about the deep oceans than we know about Venus, Mars, and the dark side of the Moon.”

Dr. Robert Fricke (MIT) in Down to the Sea in Robots,
Technology Reports, Oct., 1994, pp. 46-75

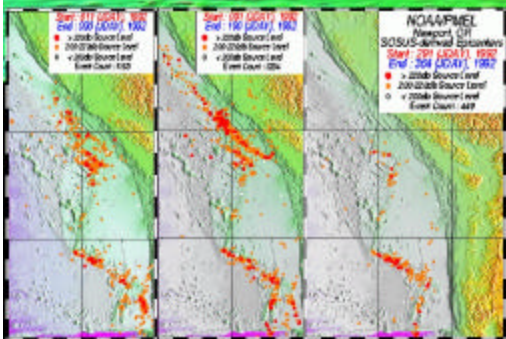
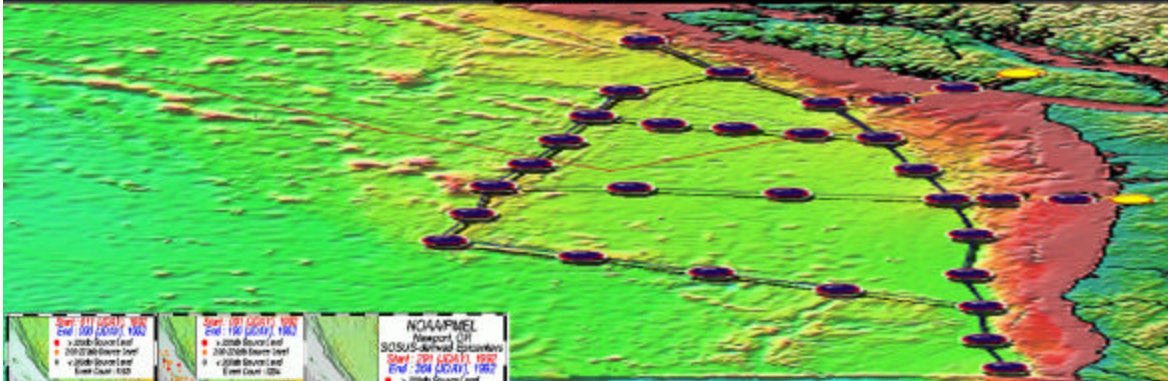
APPENDIX 1

NEPTUNE CANADA SCIENCE REPORT SUMMARY



NEPTUNE Canada Science Report

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The images on the cover all occur in the body of the report. From top to bottom, they are

- *Ocean surface productivity in 1999, as measured by the SeaWiFs satellite. Red is high productivity, blue is low. (Figure 8)*
- *Conceptual design of a mid-depth buoy carrying acoustic sensors for measuring motion and mixing in the upper ocean, linked to the NEPTUNE array.(Figure 10)*
- *A black smoker on the crest of the Juan de Fuca ridge and associated animals. (Figure 4)*
- *The topography of the sea-floor, with a conceptual diagram of the NEPTUNE backbone array. (Figure 1)*
- *The locations of earthquakes detected through underwater sound measurements during three different periods of time.(Figure 7)*

Prepared for the Institute of Pacific Ocean Science & Technology

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NEPTUNE Canada Science Report

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EXECUTIVE SUMMARY

The primary objective of the Canadian NEPTUNE Science Planning Workshop held in Victoria, B.C. on March 3-4, 2000, was to gauge the level of interest in NEPTUNE among Canadian earth and ocean scientists. A secondary objective was to begin identifying science projects that Canadian researchers could contribute to an international effort. The level of attendance and positive participation by key Canadian scientists exceeded our expectations. The compelling and original preliminary research proposals developed during the meeting now provide the scientific justification and momentum required to move NEPTUNE Canada through the remaining feasibility study phase into development of a full-fledged program proposal.

Important scientific programs requiring a system like NEPTUNE were identified in three major areas:

- Plate Tectonics and Earthquakes
- Climate Change
- Biodiversity and Earth's Major Ecosystems

The workshop concluded that the project team should proceed with a second phase involving:

- Working with the U.S. NEPTUNE organisation to define the organisational structure and Canada's role in it.
- Detailed experimental planning and prototype development.
- Detailed network engineering and implementation planning.
- Promotion of NEPTUNE to Canadian industry and planning for industry participation.
- Planning for education and public access.

SUMMARY REPORT OF WORKSHOP

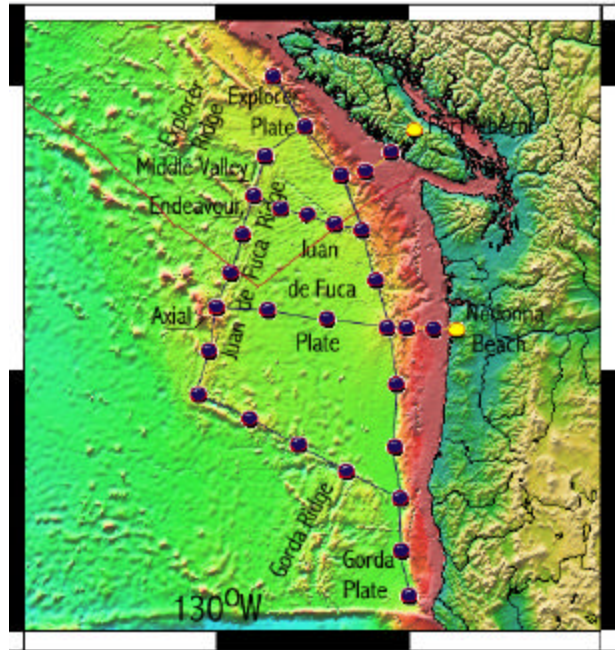
INTRODUCTION

NEPTUNE is a US/Canada initiative to provide

- 20-30 years of multidisciplinary observations of a scientifically significant ocean area, including the sea floor and the water column above it, with the time and spatial breadth and resolution needed to describe major processes that influence climate, resource abundance, and geological stability, and so link human society to the evolution of the world's oceans.
- 'Community' data in near real time for science, education, and public outreach.
- Electrical power from shore and high speed data flow to research centres on land from a network of remotely operated observatories stationed in the deep sea.
- Control of observing systems from shore, independent of weather.
- A built-in capacity for addition of new sensors or experiments and expansion to meet future needs.

Installation of the submarine cable network that would carry fibre optic communications (1-10 Gbps) and electrical power (50-100 kW) to the seafloor observatories could begin in 2003.

Figure 1: Conceptual diagram of NEPTUNE backbone network. Each blue 'button' represents a junction box where equipment up to 50 km away could be connected to the network.



NEPTUNE is proposed for the Northeast Pacific because

- The Juan de Fuca plate is the only oceanic plate that undergoes a complete range of plate tectonic processes, yet is small enough and close enough to land-based infrastructure that it is practical to instrument the entire plate.
- Observations on the scale of the Juan de Fuca plate would contribute significantly to the understanding of practical issues, such as earthquake hazards, impacts of climate change on fisheries, and the assessment of environmental impacts of industrial activities in the deep ocean.

A US design study begun in 1998 under the leadership of Dr. John Delaney (University of Washington) has identified scientific objectives, potential community experiments, educational opportunities and technical challenges. The study includes an estimate of project costs and identifies potential funding sources, all from the US perspective. Canada has been invited to become a partner with the US in NEPTUNE.

A science planning workshop was held in Victoria, B.C., on March 3-4, 2000, as part of the Canadian NEPTUNE feasibility study. This study is documenting the potential benefits to Canada of participation in NEPTUNE and developing options for implementation, management, operation, and funding. The study is funded by the Department of Fisheries and Oceans, Department of National Defence, Natural Sciences and Engineering Research Council, and the Information, Science and Technology Agency of British Columbia. The Institute for Pacific Ocean Science and Technology is conducting the study.

The first objective for the Canadian study was to evaluate the level of interest in NEPTUNE among Canadian scientists. An information package, including a request for expressions of interest, was sent to an extensive list of Canadian earth and ocean scientists and engineers prior to the workshop. Enthusiastic responses were received from universities and government laboratories all across Canada. Appendix 4 contains summaries of the expressions of interest.

At the Victoria meeting, participants worked to consolidate these expressions of interest into a few major, integrated, cutting-edge Canadian science programs. The workshop also addressed the potential benefits of Canadian participation in NEPTUNE and considered what capabilities NEPTUNE should have to meet Canadian needs.

The Science Planning Workshop was attended by 57 people. This number included 29 scientists — 11 of them from Eastern Canada — representing research groups involving several times as many scientists and students. The attendees also included a number of industry representatives and officials from both federal and British Columbia governments. A list of attendees is provided in Appendix 1.

The first day of the workshop was devoted to an information exchange, including a review of the US NEPTUNE study and a series of overviews of Canadian interests in science, public education and outreach, and industrial participation. Five working groups were established to develop integrated science plans in what were seen as the key areas. These groups met on the morning of the second day. The afternoon of the second day began with brief presentations of the working group results, and then moved on to a discussion of the next steps in the Canadian NEPTUNE planning process. The workshop agenda is presented in Appendix 2. Workshop proceedings are also attached as Appendix 3.

PRINCIPAL CONCLUSIONS

Three major scientific issues were identified for which there was significant interest and leadership capability within the Canadian scientific community, where the resulting knowledge would have significant practical benefits for Canadians, and where NEPTUNE's capabilities would permit significant advances that would be difficult to achieve in any other way.

These scientific issues are:

- Plate Tectonics and Earthquakes
- Climate Change
- Biodiversity and Earth's Major Ecosystems

SCIENCE ISSUE 1. PLATE TECTONICS AND EARTHQUAKES

The concept of 'continental drift' is as important to our understanding of our planet as the idea that the Earth orbits the Sun. Acceptance of continental drift theory has come only in the last 50 years. Earth scientists are still making rapid advances in understanding what it means to live on a planet with a mobile crust. This has great practical importance. Most earthquakes are caused by stresses due to the motion of the crustal plates. Recycling of the plates under the edges of continents produces volcanoes: the 'Ring of Fire' around the Pacific. The creation

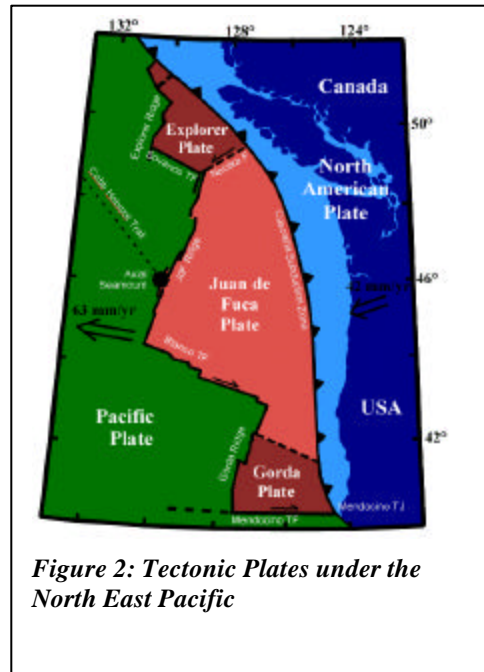


Figure 2: Tectonic Plates under the North East Pacific

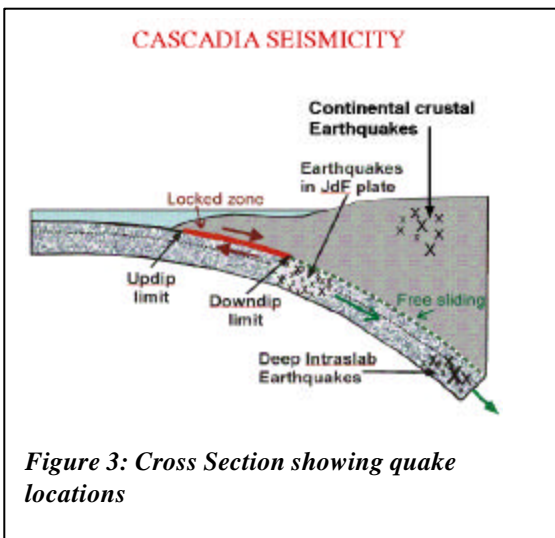


Figure 3: Cross Section showing quake locations

of new crust at the crests of mid-ocean ridges controls the chemical composition of ocean water and has been responsible for the formation of many types of ore bodies. One topic of immediate practical interest to Canadians is a better understanding of how the earthquakes that affect western Canada are generated and how their energy propagates through the crust. The subduction of the Juan de Fuca plate beneath the North American plate causes earthquakes. A major event could occur at

any time. More than \$38 million is spent every year on seismic upgrading to structures and facilities in southwestern British Columbia, according to a 1994 survey of only 70 organisations by the Emergency Preparedness for Industry and Commerce Council.

Better understanding of earthquake energy propagation and ground motion could identify critical areas where expenditures should be focused. Research in this area is a primary goal of NEPTUNE.

There is intense public interest in the dramatic processes taking place along the crest of the Juan de Fuca Ridge, including submarine volcanoes and hydrothermal vents with their bizarre life-forms. The pilot Marine Protected Area on Endeavour Ridge is a region



Figure 4: *Hydrothermal vents found on the Juan de Fuca Ridge crest support an extraordinary ecosystem.*

of specifically Canadian interest. There are opportunities to pioneer and demonstrate new Canadian technology, e.g. a "Canadarm for Inner Space." The Explorer Plate, one of the world's most seismically active seafloor regions, is entirely in Canadian waters. Many deposits of minerals now on land in Canada originated through fluid flow in ancient midocean ridge crests or subduction zones. Better knowledge of modern processes will improve the identification and economic assessment of potentially useful

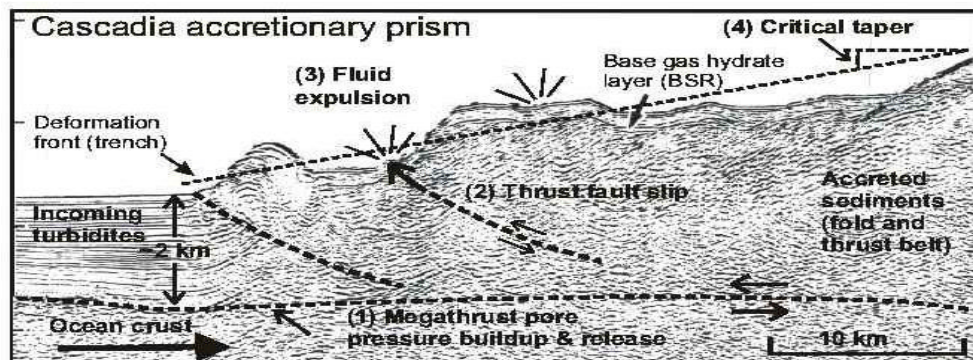


Figure 5: *Cross-section of the accretionary prism showing relationships between sediments, faults, fluid flow, and gas hydrates.*

deposits on land.

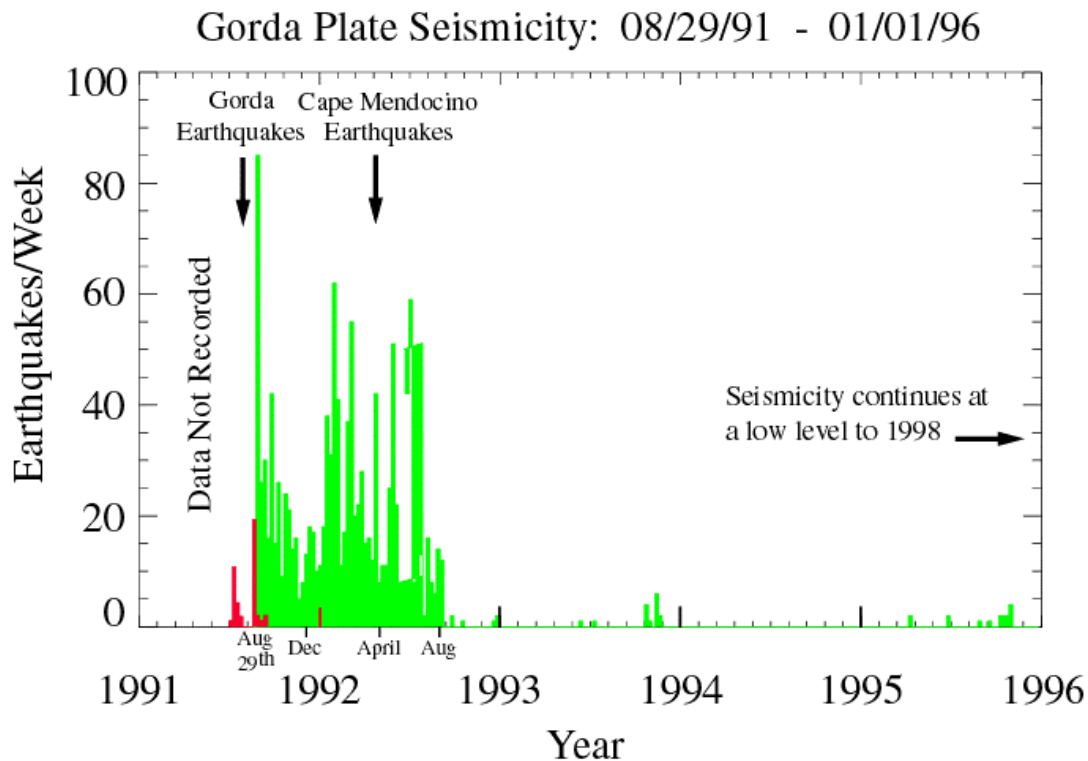


Figure 6: Time series of seismic events on the Gorda Plate. Events detected with seismographs on land are in red. The green histogram shows events detected with the SOSUS underwater sound surveillance system, which cannot record the direction of movement or separate S and P waves.

NEPTUNE has unique capabilities for improving scientific understanding of nearly all aspects of plate tectonics, from the creation of new crust at the mid-ocean ridge to the destruction of plate material as it is subducted under the continent. It will support an array of sensitive seismometers offshore for the long period needed to accumulate data from the many small earthquakes that occur in and at the boundaries of the oceanic plates. It will provide the infrastructure for direct measurements of motion across the subduction zone and ridge. Continuous monitoring of sites on the ridge crest will allow measurement and experiments to be changed, started, or stopped in response to observed changes. This provides opportunities to study closely the resilience and regenerative capacity of hydrothermal vent communities in relation to environmental change. The observatory network will allow comparisons between geologically contrasting sites.

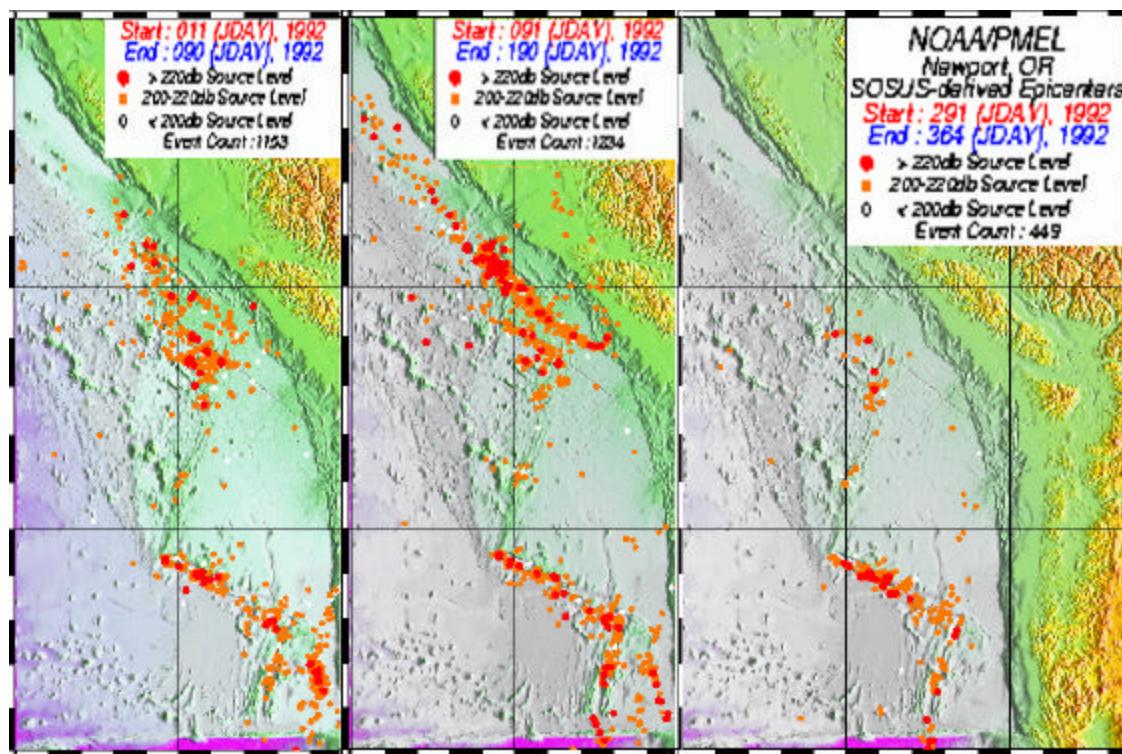


Figure 7: Seismic events detected with the SOSUS array. The left panel shows locations of events in the first three months of 1992, the middle panel shows events in the second three months of 1992, and the right panel shows events in the last three months of 1992. Activity on both Explorer and Gorda plates changes dramatically with time.

The following are examples of the scientific questions identified at the workshop, related to plate tectonics and earthquakes:

Interaction between the oceanic and continental plates in the subduction zone (Plate Tectonics Topic 1)

- What is the variation of stress and strain along the fault between the subducting oceanic plate and the overlying continental plate?
- To what extent does the subducting oceanic plate serve as a 'wave-guide' directing seismic energy and what implications does this have for earthquake hazards?
- What is the possible relationship between shallow intraplate seismicity and the 'big one' in the locked zone'?
- What is the relationship between subduction and earthquakes on lateral faults such as the Seattle fault and the one recently discovered in the Strait of Georgia?
- What is the coupling between earthquakes and ground motion?
- What are the mechanisms responsible for earthquakes in the accretion zone?

Interaction of magmatic, tectonic, hydrothermal, and biological processes at hydrothermal vents. (Plate Tectonics Topic 2)

- How is the variability of hydrothermalism (fluid composition, temperature, flow rate, plume characteristics) mineralization, and subsurface hydrology related to magmatic episodes (deep, shallow) and tectonic episodes (extension)?

- What are the patterns of fluid movement within the newly formed crust, and how are these related to eventual crustal structure and the microbial ecosystem within the crustal rock?

Geodynamics (Plate Tectonics Topic 3)

- How does the motion of a plate relate to its deformation?
- Is Explorer Plate deforming at a rate that absorbs the subduction energy?

Expulsion of Fluids from the Wedge of Accreting Material (Plate Tectonics Topic 4)

- What controls the location, rate, and composition of fluid discharges from the subducting material?
- What are the links between fluid discharge and volcanism? How does fluid discharge affect the initial conditions for volcano development and the distribution of fractures?

SCIENCE ISSUE 2. CLIMATE CHANGE

How the Earth's climate is controlled and how it is likely to change in response to human activities may be the overriding scientific question of the time. The ocean plays a large part in the climate system, transporting about half of the heat annually exported from the tropics to the polar regions, and absorbing about one-third of the CO₂ emitted from human activities. More than 80% of the carbon mobile on time scales of centuries or less resides in the ocean. We are woefully lacking in understanding of the details. Without confidence in our understanding of the details, we cannot make confident projections about the evolution of the climate.

Canadians will benefit from the contribution to an improved ability to quantify changes in ocean climate and a better understanding of the ocean's role in the global climate made by NEPTUNE's continuous all-weather long-term observations. Canada is faced with serious decisions regarding climate change and international efforts to reduce the impacts of human activities on climate. Any responsible course of action is likely to have big impacts on the Canadian life-style and economy. Projections of future climate scenarios depend on computer simulations of the global climate system. The oceans are as important as the atmosphere, but not nearly so well modelled. Improved ocean models require a better knowledge of ocean mixing and ocean/atmosphere interactions in high winds.

Canadians will also benefit from better knowledge of changes in the eastern North Pacific Ocean. The 1997 wholesale value of fisheries and aquaculture production on the Pacific Coast was \$982M. A number of important fish stocks have undergone dramatic changes over the last few decades, including Pacific salmon and Alaskan pollock. These changes appear to be correlated with changes in the ocean, but better monitoring of ocean conditions is needed if we are to ever have more than a sketchy picture. Better knowledge is also needed with respect to changes in the ecosystems of which the fish stocks are only a part.

Canadians have a particular interest in long-term observations of the response of the California Undercurrent to climate variations like El Niño. This northward-flowing subsurface current is the main source of the nutrients that fuel the marine ecosystems off the west coast of Vancouver Island and in Juan de Fuca Strait and the Strait of Georgia. Better understanding of its variations and their connections to the overall North Pacific climate system are essential for assessing the potential impacts of climate change on the Canadian Pacific coast. Our ability to achieve this critical understanding will be enormously enhanced because of the long-term observations possible with NEPTUNE.

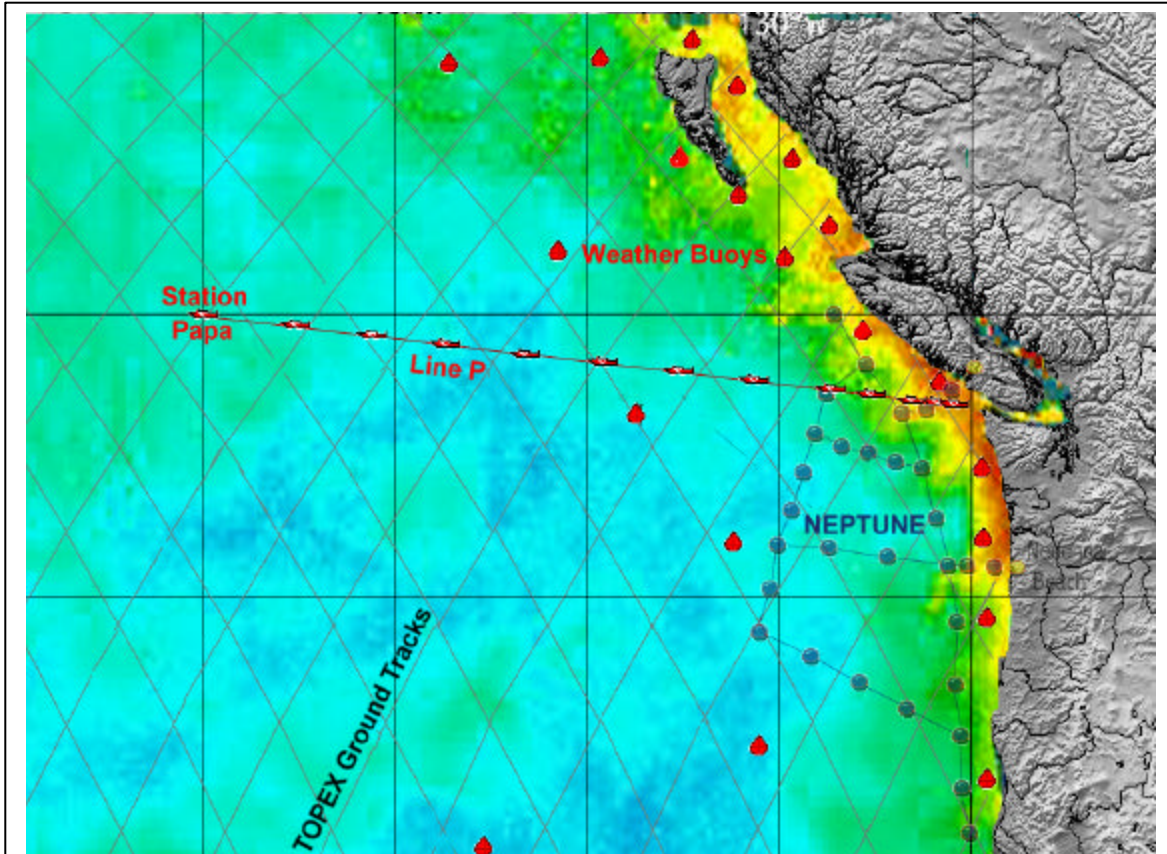


Figure 8: Ocean productivity patterns in 1999 (red is high, blue is low) as observed with the SEAWiFs satellite system, together with NEPTUNE and existing ocean climate observing systems in the Northeast Pacific.

NEPTUNE can complement the ship-based Line P/Station P time series, one of the world's longest ocean data sets, by providing a picture of what is going on in periods when costly ships are not available. Similarly the spatial extent of the NEPTUNE network will complement experimental systems such as the ARGO profiling floats by providing information on how well an individual float represents conditions in the surrounding area. NEPTUNE will also complement surface weather buoys and satellite measurements by providing simultaneous measurements in the underlying water column. The range of space and time scales of ocean variability that can be measured by the NEPTUNE network will make its results useful in designing climate observing systems

elsewhere and assessing the representativeness of their data. The advantages of extending NEPTUNE farther offshore to better sample the Alaska Gyre and the North Pacific Subtropical Gyre should be examined.

Real-time data from fixed locations will provide a basis for developing and testing computer models of the ocean for seasonal forecasts and climate change projections; the cost of obtaining equivalent data by other means would be prohibitive. Leaders of ocean climate modelling initiatives currently underway in Canada have expressed interest in using the NEPTUNE data stream. NEPTUNE nodes along the continental margin are ideally placed to observe the California Undercurrent.

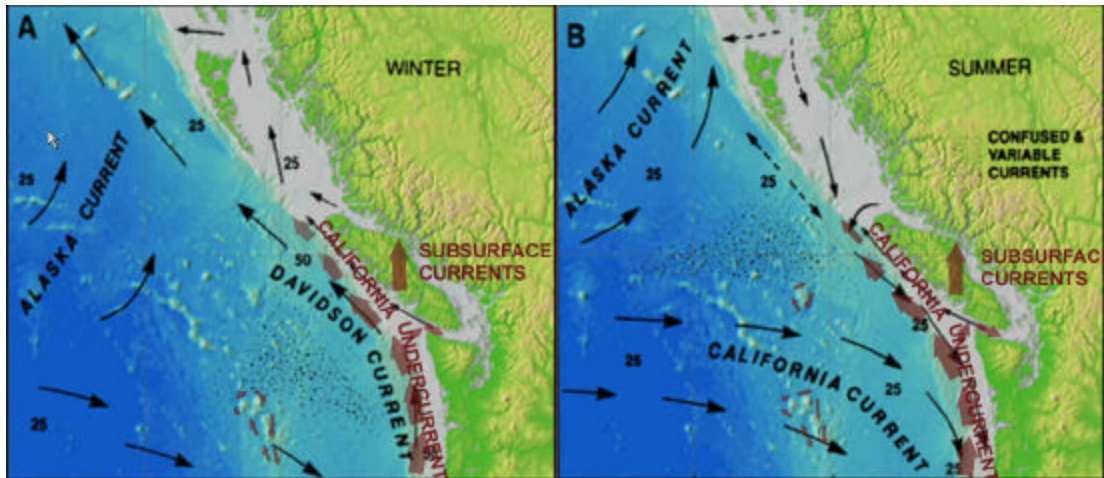


Figure 9: Surface and subsurface currents off the Pacific Coast in winter (A) and summer (B)

NEPTUNE offers unique possibilities for measurement of ecosystem components. Active profiling systems carrying light sensors and chemical scanners can be raised and lowered through the productive upper layer, thanks to ample electrical power. Ample electrical power will also permit the use of active acoustic observations of water movements and the numbers and behaviour of zooplankton and fish. High-capacity communications reduce the need for onboard data processing and storage, and provide the ability to adapt to changing conditions. NEPTUNE's capabilities could stimulate the advancement of technology in areas such as automated plankton counting.

The continuous all-weather observation and communications available with NEPTUNE offer a unique capability to document the effects of extreme weather events from the surface of the ocean down to the seabed. A single extreme event may produce greater changes than otherwise happen over an entire season or even several years. Improved understanding of the effects of extreme events on the shallow continental shelf would improve the safety and reliability of structures and undersea pipelines and cables.

The following are examples of scientific questions identified at the workshop, related to climate change:

Type of climate change occurring and its effects on the productivity and resources in the marine environment (Climate Change Topic 1)

- What are the time and space scales of changes in the North Pacific's ecosystem, and specifically in areas of interest to Canada?
- How can we separate climate change from natural variability, in the North Pacific and in the ocean in general?
- What measurements are necessary to detect climate change in the North Pacific and in the ocean in general?

The California Undercurrent (Climate Change Topic 2)

- How does the California Undercurrent change between seasons and from year to year?
- How do variations in the California Undercurrent relate to changes in North Pacific weather patterns?

Ocean modelling (Climate Change Topic 3)

- How well can we model and predict the behaviour of the ocean?

Effects of extreme weather on the ocean (Climate Change Topic 4)

- What happens in the ocean's upper layers during extreme weather?
- How do events at the surface affect the deeper parts of the ocean?
- Where and when does mixing occur in the interior of the ocean?

Effects of extreme events on the continental shelf (Climate Change Topic 5)

- How do extreme events affect the surface habitat and sediments in shallow waters?

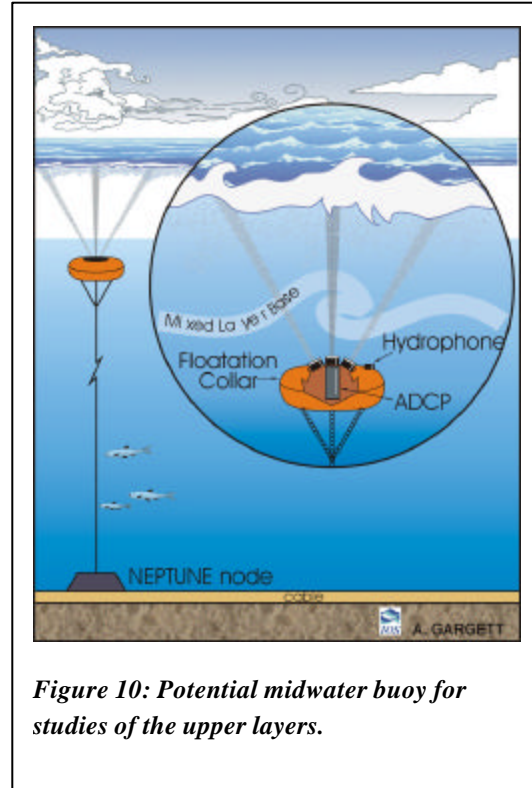


Figure 10: Potential midwater buoy for studies of the upper layers.

Science Issue 3. Biodiversity and Earth's Major Ecosystems

We know very little about the largest and most biologically diverse environment on our planet. The deep sea is the most pristine habitat left, and may be one of the few areas where biodiversity can still be studied in a context free of significant human alteration. We have great difficulty making convincing and informed assessments of the impacts of proposed mega-projects such as the oceanic disposal of CO₂ extracted from electrical power plants, other industrial waste disposals or the extraction of needed mineral resources. There have been very few studies of deep-sea animals and their role in the



Figure 11: Earth's surface

global cycles of nutrients, carbon, and contaminants. A growing world population and increasing industrial development will intensify pressures on the ocean.

The ocean depths that exceed 1000 m cover 62% of the Earth's surface, which is twice the area of all the land. According to a 1997 estimate, the open ocean contributes almost 25% of the 'value' of the world's 'ecosystem services,' mainly in gas regulation and nutrient cycling. Biodiversity in the seafloor community is astonishing, but the limited information makes even the number of species (up to 10 million!) the subject of scientific controversy.

Nearly all deep-sea communities depend for their food on events at the surface, such as plankton blooms or the death of larger fish and mammals. We know little about how these biological communities respond to natural events and human disturbances or resource extraction.

This is an emerging area of great scientific importance, an area in which Canadian scientists are already among world leaders. The unique capabilities of NEPTUNE will permit great strides in a relatively short time. The resulting knowledge will be in demand for the assessment of a variety of proposed activities. Application of Canadian expertise would provide a new business opportunity. Canadian mining companies and Canadian suppliers to foreign mining companies will need information on the magnitude and effects of natural perturbations to develop mining operations on hydrothermal deposits. Leadership from Canada will contribute to Canada's stature internationally with respect to issues related to the ocean and the environment.

NEPTUNE is the first system that can provide intensive and comprehensive observations of the deep-sea ecosystem at a number of sites, over a long period of time. It is also the first system to permit ongoing control of observations and experiments on the seafloor as results come in. NEPTUNE will span a range of environments, including the rocky ocean ridge crests, sedimented basins, and a continental margin upwelling zone where

eddies and jets carry plankton blooms offshore. The multidisciplinary community data from NEPTUNE will provide the essential context for interpreting observed change.

The design and installation of NEPTUNE will require detailed surveys of a large area. These one-time surveys provide a unique opportunity to sample and map the benthic fauna over an entire oceanic plate, at a low incremental cost.

NEPTUNE will include observing systems directed at improving understanding of the ecosystems around hydrothermal vents. These systems will provide the knowledge needed to design, carry out, and interpret ocean mining experiments, using these same observing systems. NEPTUNE will be in place for a long enough period to fully assess system recovery.

The following are examples of scientific questions identified at the workshop, related to biodiversity and the deep-sea ecosystem:

Effects of events in the upper ocean and continental margin (Biodiversity Topic 1)

- How does the ecosystem at the bottom of the ocean respond to events in the atmosphere, upper ocean, and continental margin? What does that response look like in time and space?
- For example, how do vertical fluxes of different types of material and processes such as storm events, which create ephemeral patches on the sea floor, impact the ability of many ecologically similar species to coexist?
- What is the role of active and passive transport in establishing patterns in deep-sea ecosystems?
- Is there a massive diversity of organisms in the plankton in a given area, or are the settling larvae simply highly selective about where they settle?

Impacts of human activity (Biodiversity Topic 2)

- Can this information be used to recognize anthropogenic impacts on deep-sea communities, for example, the effects of climate change, ocean dumping, dissolved pollutants, reduction in available food supply and microhabitat via the number of vertebrate carcasses reaching the seafloor.

Relationship between the deep-sea community and the sub-sea-floor environment (Biodiversity Topic 3)

- How does the deep-sea community depend on sub-sea floor hydrology and on the transport of elements and nutrients from beneath the sea floor into the water column?
- Similarly, how does the deep-sea community affect the transport of elements downward into the sub-sea floor domain?

Environmental consequences of ocean mining (Biodiversity Topic 4)

- Monitor a selected small inactive or weakly active sulfide mound in its steady state for background measurements: particulates in the water column, biology on the mound.
- Simulate mining of a polymetallic sulfide mound with a television-guided grab and monitor subsequent changes.

Science Issue 4: Getting The Most out of NEPTUNE

NEPTUNE, and related preparatory work, will also permit advances in other areas of Canadian interest.

One good example of this is the study of the immense reservoirs of gas hydrates in the accretionary prism along the continental margin. Gas hydrates are solids, rather like flammable ice, formed mainly of methane and water, which are stable over a range of temperature and pressure conditions. They are a potential energy resource, thought to equal all known reserves of conventional hydrocarbons. Methane is also a greenhouse gas, and the melting of continental shelf gas hydrates as a result of global warming could have serious effects.

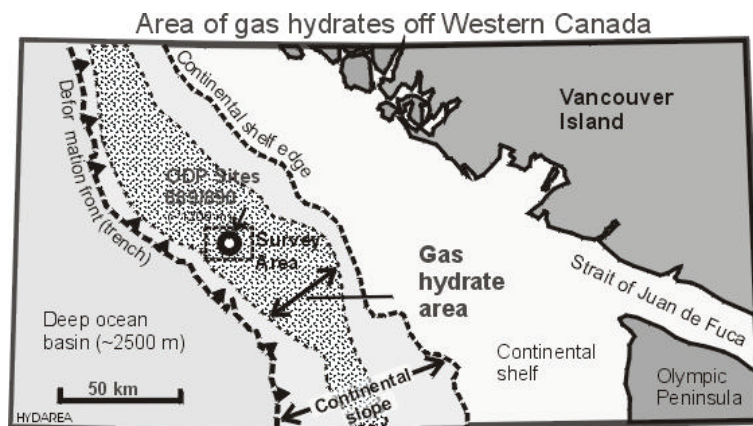


Figure 12: Potential gas hydrate deposits off Vancouver Island.

to determine the extent of Canadian reserves of gas hydrates. Understanding the potential interaction of climate change and gas hydrate deposits could have policy implications favouring early extraction and consumption. Significant extraction or warming-induced melting would affect the stability of the nearby seafloor, possibly setting off turbidity currents that could damage pipeline and cable installations on the continental shelf and margin.

Surveys needed to obtain information on underlying geological structures for siting NEPTUNE seismometers and other systems on the continental margin could be adapted to delineate gas hydrate deposits. NEPTUNE will provide the infrastructure for monitoring changes in gas hydrate deposits at a few sites over a long period, and for relating the observed changes to changes in the overlying ocean environment. NEPTUNE will also provide the infrastructure for monitoring concentrations of methane dissolved in seawater.

The amount of gas hydrate in the continental margins off the Pacific Coast of Canada and the US is poorly known. Some exposed outcrops occur, which may be eroding. Current rates of erosion are not known, nor are the mechanisms and rates of formation. It would be of considerable interest

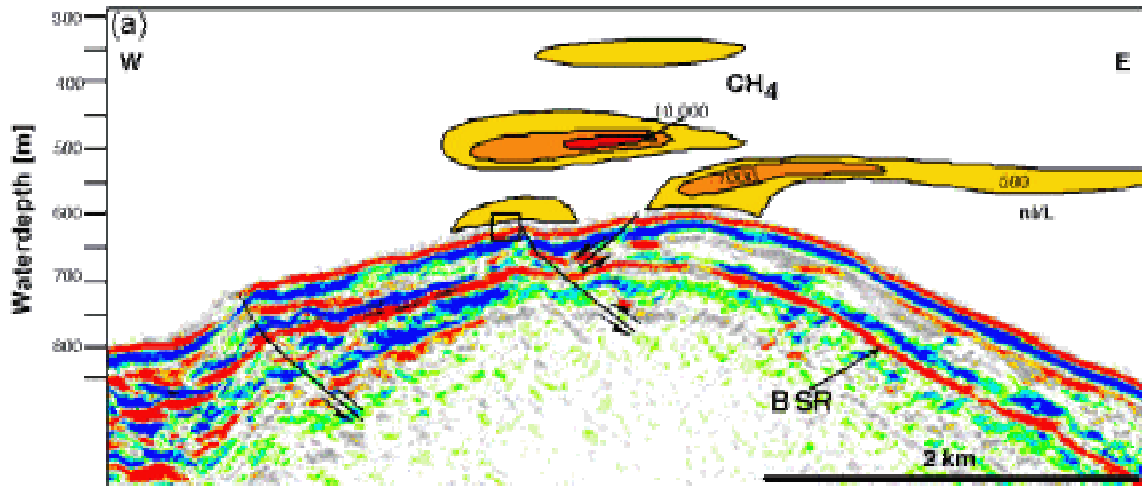


Figure 13: Plumes of dissolved methane above gas hydrate outcroppings on the continental margin off Oregon.

The following are examples of scientific questions identified at the workshop, related to gas hydrates:

The potential of gas hydrates as an energy resource

- What is the potential of gas hydrate deposits as an energy resource? What is the distribution and abundance? Its vertical structure?
- What controls fluid expulsion from gas hydrate deposits (cold seeps)? Are they continuous or episodic? What determines the locations? How is it related to seismicity?

The potential role of gas hydrates in global warming

- What are current natural rates of release? Is methane released continuously or episodically? What is the hydrogen sulfide content?
- What are the drivers for methane release and how do they relate to release magnitudes?
- What is the 'renewal' mechanism for gas hydrates and the rates of renewal?
- What is the role of gas hydrates in the overall global carbon budget?
- How would rates of release change under various 'global warming' scenarios?

Safety issues related to gas hydrates

- What is the relationship between the natural release of hydrates and slope stability? Does hydrate release play a role in the generation of turbidity currents?
- Does the release of methane and hydrogen sulphide from gas hydrates have any impact on fish habitat?
- What is the potential impact of industrial extraction on ground stability, and what countermeasures are most appropriate on the seabed?

Industry Participation

The Science Planning Workshop was seen as a precursor to industrial involvement, and little effort was devoted to soliciting industrial participation in the workshop. Nevertheless several industry representatives attended and contributed actively.

Some of the areas identified as of potential interest to Canadian industry include:

- Sea floor surveys for the installation of NEPTUNE and its various components.
- Design, development, testing, construction, and installation of components of the basic network system: cable, shore landings, communication and control systems, nodes, and shore control systems.
- Design, development, testing, construction, and installation of the scientific equipment, including remotely operated observatories, remotely operated vehicles, manipulators, samplers, passive and active acoustic sensors, chemical sensors, geophysical sensors, oceanographic sensors, systems for communicating between NEPTUNE and satellite buoys or near-surface sensors.
- Operation and maintenance of the system, including both offshore and onshore components, and data management and archiving.
- Analysis, interpretation, and application of the information resulting from NEPTUNE, and planning and conducting industrially motivated experiments using NEPTUNE.
- Education and public outreach, and development of products for education and public awareness.

The ability of Canadian industry to take advantage of the many opportunities offered by NEPTUNE clearly depends on being well informed. It also depends on an early decision on Canadian participation and on the nature and structure of the participation arrangements.

The technology developed for NEPTUNE will have other applications. Cabled sea floor observatories will be installed elsewhere. Much of the technology will have applications ashore and outside the research sector. Some of it will be suitable for use on automatic, disconnected systems. The potential market is much bigger than NEPTUNE.

The Science Planning Workshop recommended a series of half-day meetings across Canada to publicize the opportunity to industry, together with a good Web site and informative mailings.

Public Access Opportunities

The public outreach and educational opportunities provided by NEPTUNE are clearly recognized. Major museums, such as the Royal Tyrrell Museum of Paleontology, have expressed specific interests, as have the Vancouver Public Aquarium, Pacific Rim National Park, and Parks Canada regionally.

The workshop identified a number of issues and questions related to public access:

- Each of the sectors (education, public outreach organisations, individual public, science/government decision makers) has different delivery and information needs.
- Should Canada focus on a particular deliverable within the overall NEPTUNE project.
- Should we attempt to target the geographic extremes, e.g., "delivering the ocean to Medicine Hat"?
- Should a separate corporation undertake mediation and/or delivery?
- Management of proprietary vs. public data and interpretation.
- Funding: Canadian research funding agencies are reluctant to fund public outreach.

The Science Planning Workshop recommended that NEPTUNE should earmark a fixed percentage of the overall budget for education and public outreach. This is the approach taken by the US NASA program.

Conclusions

1. There is strong scientific interest in NEPTUNE in Canada, from many different scientific disciplines and from coast to coast.
2. Excellent ideas for experiments have emerged, together with good opportunities for international collaboration.
3. NEPTUNE could have a major impact on our understanding of earthquakes, and our ability to predict them and their effects.
4. NEPTUNE could make an important contribution to our understanding of ocean climate change in the North Pacific and of related changes in the ecosystem, including fish stocks and toxic algae. It would also contribute to a better understanding of the ocean's role in global climate, and improved ability to model and predict ocean currents and productivity. Extension of the network to the northwest would allow observations in an area more representative of the overall Alaska Gyre.
5. NEPTUNE could greatly advance our knowledge of the species-rich deep-sea ecosystem, which occupies the largest habitat on the planet. Observations and experiments using NEPTUNE could reveal how this ecosystem responds to naturally occurring environmental perturbations, providing the information needed to predict effects of expansion of offshore industrial and waste disposal activity into the abyss.
6. There are excellent opportunities for Canadian industry, which could lead to further business as the idea of cabled undersea laboratories gains a foothold.
7. The opportunities for education and public access are enormous. There is well-established public interest. A fixed percentage of the overall budget should be earmarked for education and public outreach.
8. The project team should proceed with the next phase, which will involve:
 - a. Working with the U.S. NEPTUNE organisation to define the organisational structure and Canada's role in it.
 - b. Detailed experimental planning and prototype development.
 - c. Detailed network engineering and implementation planning.
 - d. Promotion of NEPTUNE to Canadian industry and planning for industry participation.
 - e. Planning for education and public access.

APPENDIX 2: ATTENDANCE LIST

NEPTUNE Workshop Attendance List and Contact Information

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John Garrett	2WE Associates Consulting Ltd. 8410 Alec Road Saanichton, BC, V8M 1S4	jgarrett@2weassociates.com	(250) 652 5750
Kathryn Gillis	Earth and Ocean Sciences University of Victoria, PO Box 3055, Victoria, BC, V8W 3P6	kgillis@uvic.ca	(250) 472 4023
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Ross Heath	University of Washington School of Oceanography 107B Marine Sciences Bldg. Seattle, WA	rheath@u.washington.edu	(206)543 3153 (206) 543 5060 Box 357940
Paul Hill	Department of Oceanography, Dalhousie University Halifax, NS, B5H 4J1	paul.hill@dal.ca	(902) 484 2266
Phil Hill	Sabbatical Address c/o Dept. Earth Sciences, Simon Fraser University 8888 University Drive, Burnaby, B.C., V5A 1S6 Department of Earth Sciences Permanent Address Institut des sciences de la mer de Rimouski (ISMER) Université du Québec à Rimouski 310 allée des Ursulines Rimouski (Québec) G5L 3A1	philla@sfu.ca philip_hill@uqar.quebec.ca	(604) 291 3856 (418) 723 1986 Ext. 1705
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Bruce Howe	University of Washington, Applied Physics Laboratory Henderson Hall, 1013 N. E. 40th St., Seattle, WA	howe@apl.washington.edu	(206) 543 9141 (206) 543 1300 Box 355640
Silva Johansen	Pacific Rim National Park 12138 4 th Avenue, Richmond, BC, V7E, 3J1	silva_johansson@pch.gc.ca	(250) 726 4716 (250) 726 7721
Kim Juniper	GEOTOP-UQAM C.P. 8888, Succursale Centre-Ville Montréal (Québec) H3C 3P8	juniper.kim@uqam.ca	(514) 987 3000 poste/extension 6603#
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NAME	ADDRESS	EMAIL	TELEPHONE
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Paul Snelgrove	Marine Institute Memorial University P.O. Box 4920 St. John's NF, A1C 5R3	psnelgro@caribou.ifmt.nf.ca	(709) 778 0652
Keith Tamburri	Canadian Scientific Submersible Facility c/o Institute of Ocean Sciences P.O. Box 6000 Sidney BC, V8L 4B2	tamburri@ropos.com	(250) 363 6332
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Jon Thorleifson	Directorate of Science and Technology Maritime Defense Research and Development Canada National Defense Headquarters Major general George R Perkes Building Ottawa, ON, K1A 0K2	jon.thorleifson@crad.dnd.ca	(613) 995 5753
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APPENDIX 2

NEPTUNE CANADA INDUSTRY REPORT

EXECUTIVE SUMMARY

NEPTUNE represents an important opportunity for the Canadian private sector. It is expected that virtually the entire project, in the USA and Canada, will be open to bids from Canadian companies, competing (or possibly in co-operation) with American companies.

There is a broad array of opportunities for Canadian companies, breaking down into three basic types:

- opportunities related to selling to the NEPTUNE Project the services, technologies and equipment required to build and operate the NEPTUNE system;
- opportunities related to using the system for experiments and testing; and
- opportunities for industry development based on the data flowing from the NEPTUNE system.

The industries with strong interests in the project include the following: ocean surveying and mapping, environmental sciences and services, scientific instrumentation, construction, ocean cables, autonomous and tethered vehicles, data management, telecommunications, bio-engineering, fishing, mining, oil and gas, public utilities, insurance, pharmaceuticals, education and media.

An added advantage of this leading edge system is the fact that it will attract scientists and science-based industries from around the world seeking to utilize NEPTUNE for their own experiments. This will open up new opportunities for Canadians to collaborate and joint venture with overseas partners.

It may also form the base of a new international export product for Canadian companies. Many people believe that NEPTUNE is but the first of many such large-scale undersea research networks destined to be installed around the world. The experience gained by Canadian companies will be in demand as these new projects are developed.

NEPTUNE project management is taking steps to ensure that Canadian industry is kept fully informed of project progress, and has every opportunity to become involved.

NEPTUNE presents an unusually broad opportunity to combine important science with strong industrial activity on the part of the Canadian private sector. Making this happen, in order to achieve a major industrial benefit for Canada, is an integral part of the NEPTUNE project plan.

INTRODUCTION

NEPTUNE, when approved, will be the world's first big undersea network to monitor the seafloor and the ocean above it. The project, planned and implemented by a USA/Canada consortium headquartered at the University of Washington in the United States, and with a Canadian base at the Institute for Pacific Ocean Science & Technology (IPOST) in Vancouver, has a planned active life of at least 30 years following a six year design and construction phase.

Project costing is still preliminary, but estimates of total project cost for design, equipping and start-up of the network and related community science infrastructure are approximately US\$200 million (in year 2000 dollars), with an additional US\$10 million per year in operating and maintenance costs. Additional funding for new experiments will come from a variety of sources.

A substantial science project, NEPTUNE also represents an important opportunity for the Canadian private sector. It is expected that virtually the entire project, in the USA and Canada, will be open to bids from Canadian companies, competing (or possibly in co-operation) with American companies.

“Our support for Project NEPTUNE is justified in that the economic benefits for Canadian industry, academia and overall employment opportunities far exceed those of the funding cost to the government.”

ASL Environmental Sciences Inc., Sidney, BC

THE OPPORTUNITIES

There is a broad array of opportunities for Canadian companies, breaking down into three basic types:

- opportunities related to selling to the NEPTUNE Project the services, technologies and equipment required to build and operate the NEPTUNE system;
- opportunities related to using the system for experiments and testing; and
- opportunities for industry development based on the data flowing from the NEPTUNE system.

Building and Operating the Neptune System

The project will use both proven services and technologies, as well as new ones designed specifically for NEPTUNE during the development phase.

- Planning the project:
 - Seafloor surveys
 - Environmental Analysis
 - Conceptual design services
- Design, development, testing, construction and installation of components of the basic network:
 - Cable network
 - Shore landings
 - Communication and control systems
 - Undersea research nodes
 - Shore control systems
 - Management and service facilities
- Scientific equipment to be installed on the network, including:
 - Remotely operated observatories
 - Manipulators
 - Samplers
 - Passive and active acoustic sensors
 - Chemical sensors
 - Geophysical sensors
 - Oceanographic sensors (chemical, physical and biological)
 - Communications systems
- Autonomous and tethered vehicles capable of monitoring, sampling, performing maintenance functions, and obtaining video images:

- Large vehicles adapted for tasks related to deployment and maintenance of network nodes and their associated experiments
- Smaller vehicles to be employed in situ at nodes to collect data, samples and visual images as required
- Subsea service equipment capable of performing such tasks as:
 - Winching scientific equipment up and down the water column
 - Ensuring that instruments and equipment are kept clean of organic fouling
 - Drilling shallow holes in the ocean floor
 - Clearing debris
 - Repairs
- Technologies for collecting, storing, archiving, finding, and massaging large quantities of data collected over decades.
- Management, operation and maintenance of the system, including:
 - Offshore servicing of the system
 - Onshore servicing of the system
 - Data management
 - Analysis, interpretation and application of the information coming from NEPTUNE
 - Management of the experiment process
- Education and public outreach:
 - Public relations
 - Development of products for education
 - Products for the media, for awareness and entertainment
 - Marketing and sales

Experiments and Testing

A major benefit of NEPTUNE to the Canadian private sector will be its availability for experimentation and testing. NEPTUNE will be a dynamic meeting place for Canada's science and industrial communities, working together to utilize this leading edge system to develop the information, technologies and equipment needed to maximize the value of NEPTUNE itself, and also to help us meet the larger objective of responsible stewardship of the ocean based on a solid scientific foundation. For example:

- Instrumentation companies will use the system to experiment with new ideas, and to test their products under development or redesign.

“In addition to being a potential supplier during the construction and operational phases, we see the possibility of renting space on one or more nodes for the furtherance of our own R&D and possibly contract work. The ability to monitor mooring and cable movement in real-time in the ocean could have significant benefits over present methods which consist primarily of either tow-tank studies or in-situ data loggers.”

Open Seas Instrumentation Inc., Musquodoboit Harbour, Nova Scotia

- Companies in the information and communications technology sector will use NEPTUNE as a test bed for new technologies in subsea communications systems.

Using NEPTUNE to Expand and Develop Industries

This meeting place of science and industry will also help to provide the scientific foundation for sustaining or redeveloping existing industries, and for developing new industries and industry segments. For example:

- Resource industries such as oil and gas and mining are unlikely to be permitted for offshore work without a more solid scientific understanding of the effect of their activities on the environment. They can use NEPTUNE to probe and understand the ocean as a safe and sustainable source of mineral and energy resources.
- Companies in the seafood industry will utilize the NEPTUNE system to help them understand the changes in currents, temperature and nutrient loads that are vital to their productivity. NEPTUNE's acoustic systems will help them observe the movements of fish stocks and marine mammals.
- Bio-engineering and pharmaceutical companies will have a practical, cost effective way to identify valuable new materials for new product development.
- The insurance industry will have, in NEPTUNE, a new generation of capability to predict and plan for catastrophic occurrences such as major storms, earthquakes and tsunamis. This can help cut losses directly through early warnings, and can also help them advise the construction industry concerning building standards and designs.

“C-CORE will explore and develop the natural link that exists between the proposed NEPTUNE project and the soon to be developed Canadian Earthquake Modeling Facility at C-CORE. One example of how these two programs could interact is for NEPTUNE to contribute geotechnical and seismological data towards C-CORE's Continental Slope Stability Initiative.”

C-CORE, St. John's, Newfoundland

- The environment industry will have, in NEPTUNE, an invaluable source of long-term data to help it understand and model the effects of climate change and man-made pollution and disruptions on the ocean.
- The education and distance learning industry will benefit from a new, reliable source of fascinating information and images.
- The entertainment industry will have access to a vast new array of exciting and entertaining images; a whole new type of “content”.

THE INTERNATIONAL PERSPECTIVE

An added advantage of this leading edge system is the fact that it will attract scientists and science-based industries from around the world, seeking to utilize NEPTUNE for their own experiments. This will open up new opportunities for Canadians to collaborate and joint venture with overseas partners.

It may also form the base of a new international export product for Canadian companies. Many people believe that NEPTUNE is but the first of many such large-scale subsea research networks destined to be installed around the world. The experience gained by Canadian companies will be in demand as these new projects are developed.

“If approved the NEPTUNE Project will do much to reconfirm Canada’s position as a global leader in marine science and technology. It will provide Canadian companies with a much deserved opportunity to showcase their skills and technologies in a high profile international project.”

Canadian Centre for Marine Communications, St. John’s, Newfoundland

OPPORTUNITIES FOR CANADIAN INDUSTRY SECTORS

The following is a summary list of the opportunities presented by NEPTUNE to the main Canadian industry sectors.

Ocean Surveying and Mapping

- A very substantial project in itself

Environmental Science and Services

- The permitting process
- Data flows for ongoing work

Scientific Instrumentation

- Off the shelf sales of many types of instrumentation
- Experimentation to develop new instrumentation
- Ongoing testing programs

Construction

- Contracts for engineering and construction of the NEPTUNE system
- New designs and standards

Ocean Cable

- Laying and engineering - a substantial ocean cable contract

AUVs and Tethered Vehicles

- New vehicle designs for multiple purposes
- Off the shelf sales to the system

“NEPTUNE will use AUVs, ROVs and buoys in conjunction with a cable network to gather and distribute data in the vicinity of Juan de Fuca Ridge. This heterogeneous system, which is in fact a sub-set of remote sensing, will be used to simultaneously study the sub-bottom, the bottom and the water column. The use of such a network will usher in yet another ocean frontier revolution.”

International Submarine Engineering Ltd., Port Coquitlam, BC

Data Management

- Off the shelf sales to the system
- New data storage, retrieval and distribution systems development
- New data collection technologies

Telecommunications

- A substantial system to be constructed
- Test-bed for new systems, technologies and applications

Marine Living Resources

- Strengthened scientific base for fisheries policy development
- Improved prediction of nutrient availability and ocean temperature
- Information on fish stock distribution and movement
- Improved weather prediction through better models of air/sea interactions and ocean currents

Mining

- Scientific testing of the conditions for mining
- Testing of samples; subsea exploration to identify deposits

Public Utilities

- Early warning system for gas, water and other utility systems in the event of cataclysmic events

Insurance

- Early warning system for cataclysmic events in some circumstances
- Better input to construction standards

Bio-engineering and Pharmaceuticals

- Search for exotic new materials

Education

- Increased knowledge for curriculum development
- Images to stimulate interest and as teaching aids

Media

- A new source of fascinating “news”
- Spectacular scenes, pictures, events for blending into features, series, specials

ACTIONS TAKEN TO INFORM INDUSTRY

The Canadian NEPTUNE management team has, from the outset, sought participation in the project from across Canada. The Canadian NEPTUNE management board includes members from across Canada. The chair of the NEPTUNE Science Committee is from Montreal, and the Chair of the project’s Engineering and Industry Committee is from Ottawa. Current and ongoing promotional efforts will reflect this basic, national policy.

A project **web-page** has been developed, and will be updated to keep industry informed of progress, commercial opportunities, and how to take advantage of the opportunities for experimentation and testing www.neptunecanada.com Related promotional materials have also been distributed to Canadian companies.

Project Management has conducted a series of **information workshops and presentations targeted at Canadian industry** in Victoria, Vancouver, Montreal, Halifax and St. John's. The schedule on these sessions and brief reports are attached.

Through these promotional activities, companies have been asked to **express their interest in the project**. This has two main purposes: to give the project an up-to-date picture of the substantive industrial interest in NEPTUNE, and to ensure that companies that are interested are alerted to opportunities as they emerge. A selection of their letters is attached.

NEPTUNE is represented on the **Ocean Technologies National Trade Team**, chaired by Industry Canada in Halifax. In this manner the Canadian government network is kept fully informed, and provided with the materials and information it needs to promote the project to Canadian industry across Canada.

The project proposal will include a request for funding for a **“NEPTUNE Science and Industry Program”** (NSIP), an unsolicited proposal program targeted at Canadian companies. It will call for proposals to be submitted jointly by companies and scientific institutions, thereby increasing dramatically the complex science/industry interface which is so important, but so difficult to realize, and the development of new technologies.

Project management will pursue an **ongoing dialogue with Canadian industry** through the web-site, articles and newsletters as appropriate, and through occasional workshops and conferences on general and specialized topics.

CONCLUSIONS

NEPTUNE presents an unusually broad opportunity to combine important science with strong industrial activity on the part of the Canadian private sector. Making this happen, in order to achieve a major industrial benefit for Canada, is an integral part of the NEPTUNE project.

“The NEPTUNE project, as outlined, represents an impressive opportunity for the collection of multi-disciplinary data of a scientifically significant ocean area. As it was presented, NEPTUNE's study results can offer tremendous benefits to Canadian scientific, business and educational communities.”

Satlantic Inc., Halifax, Nova Scotia

NEPTUNE CANADA Industry Presentation Schedule

WEDNESDAY, MAY 24, 2000

VICTORIA/SIDNEY

Location: Institute of Ocean Sciences, 9860 West Saanich Road, Sidney
NEPTUNE contact Dr John Garrett. Tel (250) 363-6574 Fax 363-6479
Jgarrett@islandnet.com

Organizer: Colin Lennox, VIATEC Tel (250) 953 6680 Fax 953 6679
Clennox@viatec.bc.ca

Time: 1200 – 1400 hrs. Sandwich lunch

Attendees: 27

MONDAY, JUNE 5, 2000

ST. JOHN'S

Location: Confederation Building, West Block, Boardroom "A"

Organizer: Randy Gillespie, Canadian Centre for Marine Communications, 155 Ridge Road
Tel: (709) 579-4872 Fax 579-0495
Rgillespie@ccmc.nf.ca
Meetings with companies at CCMC, in the boardroom.

Time: 0900 – 1200 hrs

Attendees: 17

TUESDAY, JUNE 6, 2000

HALIFAX

Location: Industry Canada, 1801 Hollis Street, 5th Floor Boardroom

Organizer: Geoff Lewis, ITC Halifax Tel (902) 426-9475 Fax 426-2624
Lewis.geoff@ic.gc.ca
Cecile Arsenault, ITC Halifax Tel (902) 426-2624 arsenault.cecile@ic.gc.ca

Time: 1300 – 1500 hrs. Meeting with Mr. David Mulcaster at 1100 hrs, and
visit to SEAMAP conference at 1530 hrs.

Attendees: 16

WEDNESDAY, JUNE 7, 2000

TORONTO

Meeting with Paul Kovacs, SVP, Insurance Bureau of Canada, 151 Yonge Street
Tel (416) 362 2031 Fax 361 5952 pkovacs@ibc.ca Time 1300 hrs.

THURSDAY, JUNE 8, 2000

MONTREAL

Location: It International Telecom, 16743 Hymus Blvd, Kirkland
Tel (514) 695-2993 Fax 695-2691
Organizer: Gerald Foley, Chairman gfoley@home.com
Time: 0930 hrs
Attendees: 8

FRIDAY, JUNE 9, 2000

VANCOUVER

Location: BCIT Downtown Campus, 555 Seymour Street
Organizer: Andrew Walls, Director, BCIT Ocean Centre of Excellence
Tel (604) 453-4131 Fax 985-2862 awalls@bcit.ca
Time: 1000 hrs. Lunch will be served at 1200 noon.
Attendees: 17

NEPTUNE PROJECT
Report on the Presentation to Industry
May 24, 2000
VICTORIA

Place: Institute of Ocean Sciences (DFO), Sidney, BC
Time: 1200 – 1400 hrs, including a sandwich lunch
Host: Colin Lennox, Consultant, Vancouver Island Advanced Technology Centre (VIATEC)
Attendance: 27

Colin Lennox introduced the presenters. John Madden and Ian Robertson gave their presentations, and the floor was then open for discussion.

It was noted that the presentation dwelt on the offshore, deep sea aspects of NEPTUNE, without specific references to the relationships with coastal science. This was a particular concern on the island, where people would see this major project way offshore, and wonder how it related to their immediate interests. Madden said that the connection with the coastal zone was very much part of the science plan, and agreed that this should be expressed in the presentation.

There was a substantial discussion on the business aspects of the project. Concern was expressed that the American side would apply US government regulations on “buy US” and small business set-asides, and this would harm the prospects of Canadian companies. There were many detailed commercial questions to be resolved, such as how would GST be handled, and whether this project would be subject to WTO rules, calling for full international tendering.

Madden said that the business model being pursued by the NEPTUNE Canada team called for a procurement process de-linked from government procurement in either country. We hoped to establish NEPTUNE as a body responsible for running all aspects of the project, including procurement. This appeared to be the objective of the American team as well. It was also important to ensure that there were Canadians represented fully in the management of the project, including procurement.

It was noted that funding from the American side was reasonably to be expected, but it might be delayed for a year. This meant that if Canadian funding could be accessed earlier, it would improve our ability to negotiate various aspects of the project, including the business model.

We stressed the importance of companies watching the web-page, and of expressing their interest in the project by writing to us on their letterhead.

Ian B. Robertson

**NEPTUNE Industry Presentation Victoria
LIST OF ATTENDEES**

Name	Company
John C. Madden	IPOST
Ian B. Robertson	IPOST
<hr/>	
Terry Curran	IOS
Carl Munn	Industry Can
representing Gary Paugh	
Mervin R. Black	Canada Customs and Revenue Agency
John Briggs	WEDC
Robin M. Richardson	AlphaOmega Capital Management Inc.
Anne Evans	Applied Microsystems
Mike Cartier	ASL Environmental Sciences Ltd.
Andrew Walls	BCIT OCE
Mark Insley	Bfound.com
R. Alan Smith	Cadence Engineering Associates Ltd.
Marc Dumais	Cannacord Capital
James Tirrul-Jones	Database File Tech Group
Brock Kaluznick	ESI Environmental Sensors Inc
L. Zack Florence	Florence, Veach & Associates, Inc
David Banbury	Hydroxyl Systems Inc.
Keith R. Elwood	Lime Kiln Group Inc. (The)
Doug Taylor	Pacific Business Intelligence
Chris Gower-Rees	PR Plus
John Watt	Quester Tangent
Bill Collins	Quester Tangent
Bob Rowe	RhoCraft Research & Development Ltd.
John McCannel	Royal Bank
Peter Rowat	RSL Com
Colin Lennox	VIATEC
Michael Muirhead	Western Subsea Technology Limited
John Garrett	2WE Associates Consulting Ltd.
Wayne Clifton	

NEPTUNE PROJECT
Report on the Presentation to Industry
June 5, 2000
ST. JOHN'S

Place: Confederation Building, West Block, Boardroom A
Time: 0900 - 1130 hrs
Host: Randy Gillespie, VP, Canadian Centre for Marine Communications
Attendance: 17

John Madden and Ian Robertson gave their presentations, and the floor was then open for discussion. The group was interested in the role of NEPTUNE in raising the profile of the oceans, and of the ocean industry. It was noted that to get the funding we should "make the oceans seem sexy". Oceans are seen by Ottawa as a poverty hole. This impression must be changed as they are, in fact, a huge resource.

NEPTUNE would probably not raise too much interest from the mining industry, but the oil and gas industry would be interested. This interest would be limited for the deep water aspects of NEPTUNE, but a set-up in the Georgia Basin would be more relevant. NEPTUNE should be careful that it does not go the route followed by the Ocean Drilling Program, where they realized too late the need to stimulate a high level of interest from industry.

One speaker asked that as the project would be supported by the government of BC, would this affect the prospects of Atlantic Canada companies? Madden replied that no, this was to be a national project, with all Canadian companies having an equal chance to participate. Atlantic Canada companies should, however, think about forming alliances with BC companies to increase their prospects.

Would the NEPTUNE project be encouraged or forced to use government or quasi-government facilities? Madden replied that some government scientists would certainly be involved, but the policy was that the project would be open fully to competition.

Had we approached the David Suzuki Foundation for funding? Our reply was that we would be doing so. The American team has had extensive discussions with environment interests, and so far the response to the project has been very positive.

One speaker was concerned that Canada has only modest experience with deep water instrumentation. It was agreed that this could be a problem in terms of the immediate prospect, but that NEPTUNE offered an opportunity to develop this capability.

It was noted that the ocean floor in the NEPTUNE area would be mapped, making the project synergistic with the proposed SeaMap program. It was recommended that we speak with the CANARIE people. It was also important that the project have a clear statement concerning intellectual property policy.

Ian B. Robertson
Attachment: List of attendees

**NEPTUNE Industry Presentation – St. John’s
LIST OF ATTENDEES**

Name	Company
John C. Madden	IPOST
Ian B. Robertson	IPOST
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Darrell O’Neill	NF Gov’t
Tom Dooley	NF Dept of Fisheries and Agriculture
Brian McShane	Ind Can
Mike Sheen	Ind Can
Randy Gillespie	CCMC
Bill Carter	CCMC
Ian R. McDermott	C-Core
Bob Robinson	C-Core
Jacqueline E. Rose	Compusult Ltd
Robert Thomas	Compusult Ltd.
Michael J Cole	Fugro Jacques GeoSurveys Inc
Ewan H Cumming	Fugro Jacques
Chris Woodward-Lynas	Guigne Technologies Ltd.
Ron Davidson	Guigne
Clayton S. Burry	NewSouth Alliance
Clarence J. O’Neill	Xwave Solutions
Valerie Howe	Xwave Solutions

NEPTUNE PROJECT
Report on the Presentation to Industry
June 6, 2000
HALIFAX

Place: Industry Canada, 1801 Hollis Street, 5th Floor Boardroom
Time: 1300 - 1500 hrs
Host: Geoff Lewis, Industry Canada
Attendance: 16

A private meeting was held prior to this session with Mr. David Mulcaster, Director General for Atlantic Canada of Industry Canada.

Geoff Lewis introduced the presenters. John Madden and Ian Robertson gave their presentations, and the floor was then open for discussion.

The meeting was interested to learn of the progress made in the United States, both technically and with respect to funding. It was noted that the Small Business Innovation Program in the US had been very good for small business, and a good model for the NEPTUNE project to follow in Canada, with its unsolicited proposal program. The idea of this latter program was strongly supported by the meeting.

The question of the intellectual property policy of the project was raised. Madden said that this was an important policy issue on the agenda for discussion. In general, however, our position was that companies should be able to retain IP rights from their work on the project unless there were strong arguments to the contrary, in specific cases.

One speaker said that it is difficult to make a project like this into a moneymaker, even though the value of the project to the economy and to society may be tremendous. Madden said that some effort might be made to at least recover costs, but that government funding was a necessity. He stressed the fact that the system would be open to contracted experiments.

Replying to a question about the level of support so far gained from the government, Madden said that Minister Anderson was supportive, and we would be working with him to develop a broader base of support.

One speaker asked about the relationship of NEPTUNE to the Canadian Geospatial Data Infrastructure initiative, which has \$60m in funding. Robertson said that there had been a CGDI seminar in Vancouver last week, organized by IPOST, and NEPTUNE was discussed there as an important potential part of the program. It will be providing huge streams of data over long periods of time, available to multi-users.

Would there be a permanent service vessel required for the project? Madden said that this would probably not be required, although it would depend on the level of servicing actually required, and also the number and type of experiments and tests placed on the system. There would not likely be a need for continual mapping, although some updating would be required over time.

Concern was expressed about the position which the US navy might take on the project. They would be worried about interference with their operations in the area. Madden said that this had already been raised with the navy. There was definitely an issue to be dealt with, but potential solutions were in sight.

Concern was also expressed about the potential for NEPTUNE instrumentation, particularly when reeled up close to the surface, of interfering with fishing. This would be considered, and some regulations for fishery might be required.

Following this meeting Geoff Lewis took Madden and Robertson to a meeting of the Steering Committee of the SEAMAP project. They had just concluded a workshop on SEAMAP at the Bedford Institute.

Madden made a brief presentation on the NEPTUNE project, and SEAMAP leader Kate Moran and her colleagues briefed us on SEAMAP. This was an initiative of Bedford, started in 1992. Phase 1 has been the development of technologies for mapping the entire Canadian EEZ, designing applications, and doing “gap analysis” to see what has already been done, and what needs to be done. Phase 2 has been launched with a “concept paper”, put together by the steering committee. They hope to send a memorandum to Cabinet this Fall.

The main point of the discussion was the potential for cooperation between SEAMAP and NEPTUNE. NEPTUNE constitutes, in effect, a customer of SEAMAP. If they go ahead, this might mean adjusting the SEAMAP work program to cover the NEPTUNE area earlier than previously planned.

Ian B. Robertson

Attachment: List of attendees

**NEPTUNE Industry Presentation – Halifax
LIST OF ATTENDEES**

Name	Company
John C. Madden	IPOST
Ian B. Robertson	IPOST
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Geoff Lewis	Industry Can
Bill MacKinnon	Bedford Institute of Oceanography, NRCan
Rick Hattin	Defense Research Establishment Atlantic, DND
Geoff Lebens	Brooke Ocean Technology Limited
Alex Hay	Dalhousie University, Oceanography
Robert A. Paul	EOA Scientific Systems, Inc.
Roddy Warnock	EOA
James W. Snow	Focal Technologies Inc
Andrew J. Keast	METOCEAN Data Systems Limited
Larry Bell	NSOI
Michael J.A. Butler	Oceans Institute of Canada
Claudette LeBlanc	OIC
Dan Wellwood	Open Seas Instrumentation Inc
Craig McNeil	Pro-Oceanus Systems Inc.
Teresa Lush	Satlantic
Steven Marsden	Xwave Solutions

SEAMAP Steering Committee Members (partial list)

Kate Moran	Leader
Richard MacDougall	CHS Atlantic
Leslie Burke	DFO
David Monaghan	DFO
Carla Dale	DFO
Brian J. Todd	NRCan
Paul Boudreau	DFO
Gary Rockwell	DFO
Eileen Pease	Dynamic Learning Inc

NEPTUNE PROJECT
Report on the Presentation to Industry
June 8, 2000
MONTREAL

Place: it-International Telecom, 16743 Hymus Blvd, Kirkland, Quebec
Time: 0930 - 1200 hrs
Host: Gerald Foley, Chairman, it-International Telecom
Attendance: 8

Jacques Levesque introduced the presenters. John Madden and Ian Robertson gave their presentations, and the floor was then open for discussion.

Status of the Project

Every undersea cable company in the world is aware of NEPTUNE since Alan Chave gave a briefing on it at an international meeting last month. Canada is not currently a supplier of submarine cable, so the NEPTUNE cable is likely to be sourced in the US. We believe that the cable supply contract is seen by the US government as the major piece of commercial opportunity in NEPTUNE. The only other piece of the project thought to be targeted for the US are the data routers in the nodes, where Cisco is already involved. The NEPTUNE team approach is to have the project open to bids from both sides of the border, reflecting NAFTA policy. The project schedule may be optimistic, given the lead times required to order cable, especially for a tailored system such as this.

Early Involvement of Canadian Industry

Early involvement by our industry was strongly stressed as being the key to Canadian participation. We should be involved as quickly as possible, and have a say in the design. Madden said that this was the intention, and was in fact a main reason for this meeting. The steps to be taken were:

1. Check the designs and costing, and make our input.
2. Identify what areas Canada can compete in.
3. Determine how best to position Canadian industry.

It was noted that the pricing lists, while detailed and well prepared, seemed to be on the low side: almost at cost level.

Financing

The meeting discussed the process for establishing the Canadian share of the project. We should have as big a position as it takes to ensure that Canadians have a fair shot at the business. The suggestion was made to look at the possibility of paying for at least the ongoing operations through provision of dark fibre for use by communications carriers to carry commercial traffic between the two cable landing points. It was also noted that Canada might come up with some funding through in-kind contributions...for example mapping by the SEAMAP program could be an in-kind contribution. On the mapping issue, Madden said that the American team were assuming that the US navy would do it for free. However the Canadian government might be uncomfortable with this insofar as the Canadian portion of the Juan de Fuca plate is concerned.

The Cable Landing

Pierre Martin noted that there might be “competition” for the facility at Port Alberni, but that in all likelihood it could be made available to the project. Gerry Foley will endeavour to obtain cost estimates.

Deliverables

Madden described the Canadian NEPTUNE project engineering inputs need at this time as:

- An evaluation and brief report on the engineering study carried out by the US NEPTUNE team, and
- Appropriate input to the review of regulatory requirements which must be met before cable can be laid.

Action to achieve this is as follows:

1. Gerry Foley to advise Madden re timing of review and possible dates for review meeting in Montreal. Madden to invite American team to review meeting in Montreal.
2. Mike Kennah to organize the review process, possibly involving an outside consultant.
3. Mike Kennah and Gerry Foley to provide information (from Teleglobe and the Canadian government) concerning the permitting process.
4. Gerry Foley to provide an estimate as to when the Engineering Review report will be completed.

Ian B. Robertson

Attachment: List of attendees

**NEPTUNE Industry Presentation – Montreal
LIST OF ATTENDEES**

Name	Company
John C. Madden	IPOST
Ian B. Robertson	IPOST
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Gerald Foley	it-International Telecom
Jacques Levesque	it-International Telecom
Mike Kennah	it-International Telecom
Stephen Silvano	it-International Telecom
Morrel P. Bachynski	MPB Communications Inc
Alan F. Mitchell	MPB Communications Inc
Pierre J. Martin	Teleglobe Communications Corporation
Kim Juniper	UQAM GEOTOP
Patrick Hally	Canadian Centre for Marine Communications

NEPTUNE PROJECT
Report on the Presentation to Industry
JUNE 9, 2000
VANCOUVER

Place: BCIT Downtown Campus, 555 Seymour Street
Time: 1000 – 1200 hrs, followed by lunch
Host: Andrew Walls, BCIT Oceans Centre of Excellence
Attendance: 17

John Madden and Ian Robertson gave their presentations, and the floor was then open for discussion.

The main focus of discussion was funding. Madden said that Canada would probably be asked to provide 20-30% of the money for the NEPTUNE project. Several speakers said that we should try to fund as much as possible through commercial channels. The main commercial opportunity was in the communications and media area. NEPTUNE would provide a huge flow of dramatic images, which would have great commercial value around the world. This should be worked on, as it would take the pressure off government funding.

Madden spoke of the possibility of having a preliminary installation in the Georgia Basin. It would be a test-bed for NEPTUNE, as well as providing useful information in its own right.

Replying to a question of where the most scientific interest in the project lay, Madden said that this remained to be seen, but there was strong interest in all aspects of the project and it could be justified on several different bases.

On the question of commercial policy, Madden said that both sides wanted the project to be de-linked from government procurement processes, with open bidding for all the work involved. This appeared to be the best approach for Canada, as we are competitive in this sector.

Madden commented on the chances of having the project approved for funding. Some good progress had already been made in the US, and there appeared to be some substantial interest within the Canadian government. He was optimistic that the project would go ahead.

Ian B. Robertson

Attachment: List of attendees

**NEPTUNE Industry Presentation – Vancouver
LIST OF ATTENDEES**

Name	Company
John C. Madden	IPOST
Ian B. Robertson	IPOST
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Guy Flavelle	WEDC
John Lau	WEDC
Bob Ostle	BC MEI
Jonn Aster	Aster Associates International
Bob Wilson	Axton Manufacturing
Andrew Walls	BCIT.OCE
Stefan Joseph	BCIT
Keith Tamburri	Canadian Scientific Submersible Facility
Ron Cartwright	Chamber of Shipping of BC
John Musil	ISE
Terry Knight	Inuktun
Michael Harvey	Kongsberg Simrad Mesotech Ltd
Ron de Silva	Pacific Fisheries R&D
Robert Selvage	S-Matrix Enterprises
Terry Thompson	T.Thompson Ltd
Trish Hall	Vancouver Aquarium
Vicki Leung	360 Networks

**NEPTUNE
CANADA
LETTERS
OF
SUPPORT**

APPENDIX 3

NEPTUNE CANADA PUBLIC OUTREACH & EDUCATION REPORT

INTRODUCTION

The deep ocean remains the largest space on the planet that we cannot penetrate easily. Its mere presence serves to fuel the fascination and imagination of all of us. NEPTUNE will share the exploration, the experimentation and the inspiration of this inaccessible world with students and citizens, young and old. People are often fascinated by the human scientific endeavours to investigate both space and the oceans. Audiences will respond both to information about NEPTUNE and to the emergent discoveries.

Public Education and Outreach form a major part of the US NEPTUNE plans. There, the NASA approach is embraced in which commitment to major funding for outreach is deemed essential. We will contribute to the vision of their Ocean Envoy program and development of NEPTUNE materials. However, there are institutions, audiences and educational systems that are uniquely Canadian thereby, requiring a separate effort.

SOME GUIDING PRINCIPLES

The Canadian NEPTUNE program will incorporate the following concepts:

- the mission to inform and educate is a major mandate of the NEPTUNE program;
- sharing the process of inquiry as well as the discoveries will underlie the outreach program;
- communication begins at the start of NEPTUNE – not as an afterthought; and
- a designated portion of scientific expenditures will be devoted to public outreach.

MAKING THE INFORMATION ACCESSIBLE

The development of the Internet over the last decade has made it possible to reach the entire populace of Canada from the deep-sea. The data delivery mechanism to scientists will be via the Internet – it is not difficult to make the outreach step to computers in every home and school. With the development of high definition TV and holographic projection, we can present the deep-sea in virtual reality. The Canadian public will have access to many types of information. These include:

- Canadian Project NEPTUNE itself, including the concept, the operations and highlight results;
- interpreted results delivered from the experimental array with regular updates;
- real-time data, including video, delivered with minimal interference by the array operator;
- some access to interactive experiments and observations; and
- gateways to the overall NEPTUNE project, US outreach and other ocean education resources.

OUTREACH MECHANISMS

We foresee three approaches to delivering information concerning NEPTUNE:

1. Information and Communication directly from Project NEPTUNE

Information about the project will be formulated by NEPTUNE staff for direct communication to the public or through intermediaries such as through the broadcast and print media. There are several strategic choices to be made in terms of the degree to which NEPTUNE is a primary processor and distributor of information to the public, and the degree to which cost recovery or revenue generation are desired.

Canadian NEPTUNE will dedicate resources to providing interpreted data from Canadian projects and access by Canadians to array information. Interactive mechanisms need definition. The Internet will form the basis for most of the information handling.

Canada will participate in the US program of coaching Ocean Envoys – people trained to interpret the Project and to represent it to audiences across the country.

2. Public Information via Second or Third Parties

Information for the general public is frequently formulated in many formats; some has re-sale value for certain businesses. NEPTUNE will endeavour to provide information or results to outside organisations or businesses that will process it for specific user groups.

Interaction with sponsors and collaborating industries will be formalised to optimise communication and to provide mutual benefits. Close interaction with US NEPTUNE is anticipated as products and users will be shared.

3. Organized Educational Programs

NEPTUNE can provide a living example of the process of scientific inquiry. We believe that its dynamic delivery and interactive mode will allow captivating educational programs that will grow with NEPTUNE. The US program is planning to formulate curricula and materials for K to 12 as well as to post-secondary levels. We anticipate working with our American colleagues to develop material suitable for both countries as well as developing some uniquely Canadian approaches. The training of young scientists at the university level can be aided with apprenticeship programs that plan, execute and analyze experiments in the deep sea.

Several centres around Canada are prime locations for public education programs. Museums, aquaria and science centres can help us develop materials to suit their formats.

DEVELOPMENT OF THE PROGRAM

Program development requires a broad vision encompassing an international setting with a Canadian context. The outreach structure must allow evolution as both audiences and technology change.

In developing Project NEPTUNE, the communications and educational value of the project have been recognised from the beginning. A Communications and Education Committee will be formalised in Phase 2. The consultation process will be expanded with the Committee acting in a steering and advisory role to the NEPTUNE Board through Phase 2 and on into project implementation. The committee will maintain a wide scope with several parallel interests: local prototype programs, Canada-wide consultation, and international involvement. Special attention will be paid to full liaison with the US-based NEPTUNE communications and education effort to ensure maximum co-operation and the efficient development of programs without overlap.

Communications are a vital part of building awareness and support for Project NEPTUNE. The Phase 2 budget includes a full-time Communications and Education Coordinator. The Coordinator will organise the many consultations with a wide variety of community and constituency groups to ensure that all possible communications and education benefits from NEPTUNE have been captured and explored, and a plan developed for this activity. Information about Project NEPTUNE has immediate educational value. Funds have been budgeted during Phase 2 to consult with the Canadian secondary and post-secondary education communities.

CONSULTATION PROCESS

People need to know about NEPTUNE and its capabilities if they are to feed back their interest, needs and goals. The process can start through a series of consultations organised around users of a particular interest. For example, information/exploration sessions should be held with the media, with web information developers, with educators, and so on. From these areas of described interest, programs can be formulated for evaluation, testing, funding and eventual implementation.

Consultation also means participation in the parallel process underway in the US. In addition, it should include a good deal of research into similar programs such as those for NASA and the Hubble Space Telescope, and Canadian efforts such as TRIUMF and the Canadian Foundation for Innovation.

ISSUES FOR CONSIDERATION

1. Structure for interaction with the US NEPTUNE outreach

Models for interaction include running a parallel program in a scaled-down Canadian version, a subsidiary program that addresses Canadian components or a satellite program that operates one part of the entire Outreach for NEPTUNE. Consideration of the benefits and costs of each approach is required.

2. Communicating with the Canadian public

Communication with the public is important for their understanding and support of the project, so it is vital that this element of the project is carefully managed.

3. Revenue generation

Some products from NEPTUNE will have re-sale value, so care should be taken to control their dispersal. However, we are involved in an international project with funding from several governments. Close cross-border co-operation is required.

4. A West Coast NEPTUNE centre

The Canadian cable landfall is proposed for Victoria harbour. This landfall can become a major focal point for public education and tourism. Investigation of existing or potential facilities and locations to develop a "Gateway to the Deep Sea" will happen early in Phase II and include consultation with established centres such as the Royal BC Museum, Pacific Rim National Park and the Vancouver Aquarium Marine Science Centre.

THE FIRST STEPS

The Outreach component will have a strong presence in NEPTUNE and thus needs an early beginning. The first steps include:

1. formalization of the oversight committee with definition of terms of reference;
2. exploration of an initial partnership with one or two extant institutions to develop a communications plan for target audiences;
3. execution of a survey of public and target audience interests to formulate a plan to address those interests in the longer term;
4. interaction with the US program to define shared and partnership activities;

5. initiation of dialogue with educators to define an inclusive process for curriculum development in the Canadian context;
6. work with Canadian researchers during the pilot program phase; and
7. work with the Victoria committee set up to investigate the feasibility of the Victoria Ocean Observatory.

CONCLUSION

Early development of an organized communication and education effort will facilitate the overall growth of NEPTUNE. Targeted communication activities are essential not only to develop widespread support for NEPTUNE but also as important goals for contributions to Canadian society.

APPENDIX 4

NEPTUNE CANADA ENGINEERING REPORT



**INTERNATIONAL
TELECOM**
GROUP

PREPARED BY:

**International Telecom Group
16743 Hymus Boulevard
Kirkland, Quebec
Canada
H9H 3L4
www.intelecomgroup.com**

SUMMARY

it-International Telecom Inc, a wholly owned subsidiary General Dynamics Advanced Technology Systems, is a technical consulting and installation company that provides a comprehensive range of services to the Telecom Industry world wide. As an organisation independent of any carrier or manufacturer, 'it' is in the unique position to offer the experience and skills usually found within the largest international carriers and submarine cable manufacturers to look at the NEPTUNE project from an installation and maintenance perspective.

We found the NEPTUNE study to be comprehensive in all aspects. The engineering is presently in overview state and will require extensive work to develop to a system design. With the limited technical information supplied on the nodes there is nothing that negates standard installation techniques.

Our engineers have undertaken preliminary route engineering as well as analysed initial pricing and engineering information. We have concluded that from an industry perspective that all assumptions and costings are consistent with industry standards.

We have analysed the lengths and the cable types and have also felt that the system is well designed and will be robust. The system will require some minor changes to optimise crossing angles with existing cables, but this will not effect the total cable length or the maintenance.

We have not examined the power requirements or the electronics that will be placed in the nodes as this is outside of our expertise.

CABLE

Each section of the route was engineered and plotted with our standard positioning software. Slack and cable types were allocated and then compared to the information provided by NEPTUNE. All data is consistent with the NEPTUNE supplied information.

After the marine survey is completed a final validation of these figures would have to be done but this would not impact the length or cable types by a significant amount.

The marine cable industry is presently enjoying a booming market and because of this there is very high demand for cable and fiber. The cost structure for the cable is typical for a project today but it would be recommended to increase the cable costs by 30% between the time of the study and the time of installation instead of the cost of inflation that has been applied in the study.

INSTALLATION

We have assumed that the survey would be conducted through the scientific community and thus at a less than industry cost has been allocated to the project.

The industry is booming and installation vessels are also in short supply. The total number of days for installation is adequate as long as in the final design the nodes are not difficult to install. Since there are finite ship resources, a ship may have to be transited to the site from as far away as Europe. The transiting times have not been included and may be a significant portion of the actual installation cost. Our calculations are based on 85% ploughing to the 1000m contour.

The project has also been broken into a multi year installation approach. It would be recommended to undertake all work at once to minimise the mobilisation costs.

No costs have been provided to work in Canadian waters if the ship is flagged outside the country. The Canadian government will charge 1/120th of the depreciated cost of the vessel per calendar month when working in Canadian waters. For example, a \$50,000,000 cable ship will be charged almost a half a million Canadian dollars per month to work in Canadian waters.

MAINTENANCE

All available information concerning maintenance was well documented and is deemed to be reasonable. We see that further cost savings may be achieved by using research facilities or private maintenance solutions instead of commercially available vessels that may be tied to existing commercial cable maintenance agreements.

APPENDIX 5

CANADIAN NEPTUNE MANAGEMENT BOARD & COMMITTEE MEMBERS

MANAGEMENT BOARD

Name	Title	Company	City/Province
Dr. John C. Madden(Chair)	President	STC Enterprises Inc.	Vancouver BC
Mr. Bill Collins	Chief Scientist	Quester Tangent	Sidney BC
Mr. Gerald Foley	Chairman	it-International Telecom	Kirkland QC
Dr. James M. Franklin	President	Franklin Geosciences	Ottawa ON
Dr. Jeremy Hall	Professor	Memorial University	St. John's NF
Dr. S. Kim Juniper	Assoc. Prof.	GEOTOP, UQAM	Montreal QC
Mr. Paul Kovacs	Vice President	Insurance Bureau of Canada	Toronto ON
Dr. Paul LeBlond	President	Global Insights Inc.	Galiano BC
Dr. John S. MacDonald, O.C.	Chairman	IPOST	Vancouver BC
Dr. James R. McFarlane, O.C.	President	Int'l Submarine Eng. Ltd	Pt Coquitlam BC
Mr. William Meehan	Exec. Director	IPOST	Vancouver BC
Dr. John Nightingale	President	Vancouver Aquarium	Vancouver BC
Mr. Calvin Shantz	Director	S&T Division, BC Gov't	Victoria BC
Dr. Verena Tunncliffe	Professor	University of Victoria	Victoria BC

OBSERVERS

Name	Title	Company	City/Province
Dr. John Davis	ADM Science	Fisheries and Oceans Canada	Ottawa ON
Mr. Jon M. Thorleifson	DSTM-5	Dept of National Defense	Ottawa ON

SCIENCE SUB-COMMITTEE

Name	Title	Company	City/Province
Dr. S. Kim Juniper (Chair)	Assoc. Prof.	GEOTOP, UQAM	Montreal QC
Dr. N. Ross Chapman	Professor	University of Victoria	Victoria BC
Dr. Earl Davis	Sr. Scientist	Pacific Geosciences Centre	Victoria BC
Dr. Jeremy Hall	Professor	Memorial University	St. John's NF
Dr. Roy Hyndman	Sr. Scientist	Pacific Geosciences Centre	Victoria BC
Dr. Colin Levings	Director	West Vancouver Labs	West Van BC
Dr. Larry Mayer	Professor	U of New Brunswick (formerly)	Fredericton NB
Dr. Steven Scott	Professor	University of Toronto	Toronto ON
Dr. Rick Thomson	Sr. Scientist	Institute for Ocean Sciences	Sidney BC

INDUSTRY AND SYSTEM ENGINEERING SUB-COMMITTEE

Name	Title	Company	City/Province
Mr. Gerald Foley (Chair)	Chairman	it-International Telecom	Kirkland QC
Dr. Morrel P. Bachynski	President	MPB Technologies Inc.	Point Claire QC
Mr. Bill Collins	Chief Scientist	Quester Tangent	Sidney BC
Mr. John Graham	Executive VP	it-International Telecom	Kirkland QC
Mr. Doug Kinsey	Officer	Industry Canada	Vancouver BC
Dr. Tom LeFeuvre	Dir. General	NRC Inst. for Marine Dynamics	St. John's NF
Mr. Ian B. Robertson	President	IB Robertson ADVISORY Inc.	West Van BC

APPENDIX 6

INSTITUTE FOR PACIFIC OCEAN SCIENCE & TECHNOLOGY (IPOST)

THE OCEANS – A VITAL BUT THREATENED RESOURCE

The oceans cover 70% of Earth's surface. They are the controllers of our weather systems. Their health and behavior affect everyone, whether living on the coast or inland. They are a major source of nutrition, and their bounty extends to vast mineral and energy resources as well as to pharmaceutical products. They are transportation highways and endless sources of recreational and cultural satisfaction.

The press of human population growth and economic activity now threatens the oceans. It is harmful to health and is threatening the fishery. Responsible human stewardship of the oceans is an urgent priority. This calls for scientific research to help us understand the oceans, to develop the technological tools needed to study, monitor, analyze this vital resource and to sustainably manage them.

IPOST

IPOST is a not-for-profit organization located in British Columbia and created to stimulate the development of a sound, active, priority-based ocean research agenda for Canada's Pacific coast and beyond. It is owned and directed by the diverse players in ocean research: the federal and provincial governments, academic interests, and the ocean industries.

IPOST's responsibility and objectivity is assured through its distinguished, highly experienced and representative Board of Directors and its autonomous, technically qualified Science and Industry Advisory Board.

SCIENCE PROGRAMMING AND PRIORITIES

As a partnership of diverse interests, IPOST acts as a catalyst to develop strategic alliances for research projects, strengthening the science and technology efforts of governments, industries and universities towards shared objectives. IPOST seeks funding from public and private sources to carry out its programming, and to fund research projects.

Seafood Sustainability is a key part of the IPOST agenda. This program looks at the scientific foundation for new fisheries management systems: for example, the development of multi-disciplinary modeling techniques to research and evaluate the multi-species stock of fish and other aquatic resources in BC's coastal waters. A related subject of high priority is science related to BC's aquaculture industry. IPOST is addressing questions such as the development of new species of farmed fish to supplement the traditional salmon farming industry, coordinated research programs for the shellfish industry, and the development of alternative aquafeed ingredients based on Canada's cereal products.

IPOST looks at the major questions of *the environmental and economic impacts of climate change and the effect of seafloor geological events* on the oceanic and atmospheric environments through the lens of applied ocean sciences and ocean technologies, and the development of new technologies. The NEPTUNE project is of primary importance in this sector of activity.

IPOST is also an advisor to the Steering Committee of the SEAMAP program currently being considered by the Government of Canada. This major program will involve the mapping of the seafloor of Canada's entire Exclusive Economic Zone (EEZ), which is the seafloor extending at least 200 miles off our coastline. The importance of this program is illustrated by the fact that extending our jurisdiction over our EEZ will increase Canada's geographic size by one-third, and add significant potential resources to our economic prospects.

IPOST is represented on the Board of Directors of the Canadian Centre for Marine Communications, based in St. John's, Newfoundland, and helps the CCMC extend its high technology mandate to the Pacific coast. Related to this is IPOST's growing working relationship with the GeoConnections program. This program of the Government of Canada brings together expertise and technology to spur the development of new applications, tools and services for the Canadian "geospatial data infrastructure". IPOST's focus is on the "marine geo-spatial data infrastructure", which involves linking the many databases on our marine resources via the Internet, and developing new ways to source, store, analyze and distribute data.

NETWORKS AND PARTNERSHIPS

The essence of IPOST's role and importance is its ability to bring together the diverse interests in our oceans and fisheries to exchange ideas, share agendas, develop joint scientific programs and projects, find the required financial resources, and put them to work. The whole, which is this coordinated work, is far greater and more powerful than the sum of the parts, which are disparate and often conflicting voices, geographically separated and lacking resources.

IPOST is developing its own Internet-based networking system to maximize the efficiency and effectiveness of its networking. This is particularly important in its efforts to bring together the academic research and private sector interests in the ocean sector in BC. IPOST is also at the heart of a number of networking and partnering activities dedicated to specific issues and objectives.

ORNEP, the Ocean Research Network for the Pacific, for example, is an international initiative which involves the linking of ocean research centers of excellence around the Pacific Ocean. IPOST is also the catalyst for the development of science based networks linking BC's coastal communities, and BC's coastal colleges and universities. These coastal networks are an essential pre-requisite to expanding BC's ocean science activity from its current concentration in the Lower Mainland area to the entire coastal region.

IPOST is an active partner with key research organizations such as the Science Directorate of Fisheries and Oceans Canada, Environment Canada, the National Research Council of Canada, and the fisheries and oceans research institutions in the universities and colleges in BC, and in Central and Atlantic Canada.

APPENDIX 7

NEPTUNE US FEASIBILITY STUDY REPORT SUMMARY

This report can be found at
www.neptune.washington.edu

NEPTUNE Canada



Feasibility of Canadian Participation in the NEPTUNE Undersea Observatory Network

Report prepared under the direction of:
Canadian NEPTUNE Management Board



On behalf of:
Institute of Pacific Ocean Science & Technology
200 – 2150 West Broadway, Vancouver, BC V6K 4L9

October 2000