NEPTUNE
North
East
Pacific
Time-series
Undersea
Networked
Experiment

Brian Bornhold
NEPTUNE Canada
Transformative research

Transformative research is defined as research driven by ideas that have the potential to radically change our understanding of an important existing scientific or engineering concept or leading to the creation of a new paradigm or field of science or engineering. Such research is also characterized by its challenge to current understanding or its pathway to new frontiers.

Steven C. Beering, Chairman, US National Science Board, 7 May 2007
Transforming the ocean sciences

“The last century of oceanography is marked most by the degree of undersampling” Walter Munk (2001)

In contrast, cabled ocean observatories will have:
• 24/7/365/25 presence, variety of sensors, selected locations
• Sampling frequencies of subseconds for most parameters
• Real-time multidisciplinary, interactive experiments

All this is possible with:
• Abundant power and high bandwidth communication
• Remote control of observatory network and instruments
• Real-time high data/imagery return (Gb/sec)
• A vast interactive data archive
Key Characteristics of NEPTUNE

- Tectonic plate scale
- Lots of power (100 kW)
- Bandwidth (Gbits/sec)
- Real-time data return & control
- Robust design; high reliability
- Available for 20-30 years
Block diagram of southwest B.C. showing the Juan de Fuca plate descending beneath North America along a subduction zone.
Neptune Canada Partnerships

Industry via NRC, UVic, IDC

International: Japan, Germany, France, United Kingdom

Victoria Oceanic Observatory

Bamfield Marine Station

U.S. partners: UW, WHOI, MBARI, JPL

12 Canadian Universities
Funding

• Approximately $80 million for 5 years
• Half from the Canada Foundation for Innovation
• Half from the BC Knowledge Development Fund
• As well, there have been contributions to specific developments (e.g., underwater High Definition Television) from CANARIE
DMAS Structure
DMAS Features

DMAS Mandate

- Make data available to researchers in (near-) real time
- Store data for long term time-series studies

DMAS Features

- Allow human interaction with instruments
- Facilitate automated, routine “survey campaigns”
- Facilitate automated event detection and reaction definition
- Store scalar data in data warehouse for easy x-correlation
- Store complex data in fast file system
- User access mostly through the web/specialized client software
Sea Cable Storage
Node insertion into TRF, MARS
Plate-scale science experiments - NEPTUNE

Canada

Middle Valley

ODP 889

Folger Passage

Barkley Canyon

Endeavour

Cross-Section

ocean crust

magma chamber

Axial

lithosphere

subduction zone

continental crust

continental lithosphere

asthenosphere

melting
Science Research Themes

- Plate tectonic processes and earthquake dynamics
- Dynamic processes of fluid fluxes and gas hydrates in the sea bed
- Regional oceanic/climate dynamics and effects on the marine biota
- Deep-sea ecosystem dynamics
- Engineering and computational research
**Shelf Break Benthic Pod**
- pan and tilt video camera
- ADCP (600kHz)
- sediment trap
- current profiler (2MHz)
- plankton pump
- sector scanning rotary sonar
- bottom pressure recorder
- hydrophone (0.5Hz-1kHz)

**Vertical Profiler**
- CTD
- oxygen sensor
- fluorometer
- transmissometer
- nitrate sensor
- carbon dioxide sensor
- multi-frequency acoustics package (including hydrophone)
- upwelling/downwelling radiometer
- ADCP (75kHz) at base

**Barkley Canyon**

**Mid Canyon Benthic Pods**
- still camera
- fluorometer
- CTD
- multibeam sonar
- microbial sensor
- plankton pump
- sector scanning rotary sonar
- hydrophone (10Hz-65kHz)

**Hydrate Outcrops**
- cameras
- temperature probes
- sector scanning rotary sonar
- Bremen Crawler (camera, CTD, benthic chamber, schlieren optics, methane sensor)

**Canyon Axis Benthic Pod**
- pan and tilt video camera
- current profiler (2MHz)
- sector scanning rotary sonar

**Legend**
- Instrument Site
- Node
- Extension Cables
- Cable Route: PL03

**Basemaps:**
- UofW: TN175
- Projection: UTM Z9N WGS84

**NEPTUNE Canada Project**
- Barkley Canyon
- Proposed System Layout
- University of Victoria
- 2007/09/26
Cascadia Gas Hydrates

- Rotary still cameras
- Thermistors
- CH4, O2, SO4 sensors
- Crawler (Bremen) – video
- Fluid flux sensor
Advanced CORK System for Ocean Bottom Boreholes

(courtesy of E. Davis)
Atmosphere

Response Variables
- Biodiversity
- Biogeochemistry
- Functional Ecology

Hydrosphere

Predictive Variables
- Climatic & Oceanographic Variability (multiple temporal & spatial scales)

Lithosphere

- Hyperbenthos
- Epibenthos
- Infauna

Water Column Group

Benthic Group
Benthic Ecology

- Conductivity-Temperature-Depth System
- Laser Optical Plankton Counter
- Profiling Winch High-volume Plankton Multi-sample Pump
- Multi-sample Sediment Traps
- Acoustic Doppler Profilers (1 ADCP and 4 Aquadopps)
- Acoustic Doppler Velocimeter (Vector)
- Rotary Sonars.
- Pan-Tilt Video Cameras High-Resolution Pan-Tilt Still Camera.
- Broadband (5Hz-20 kHz) Hydrophone
- *in situ* Microbial Metabolism Package
Ocean Dynamics

- CTD
- Oxygen sensor
- Fluorometer
- Transmissometer
- Nitrate sensor
- CO$_2$ sensor
- Upwelling/downwelling radiometer
- Broadband hydrophone
- ADCP
- Bottom Pressure Sensor
Vertical Profiler System (VPS) for NEPTUNE CANADA

Instrument Package

Layout of Sensors

Platform
Tracking marine mammals

- Receivers will identify and track whales both small and great.
- Record migration tracks, abundance and communication behaviour
- Examine ship interactions

Killers 100 Hz to 20 kHz
Great whales 10 to 1000 Hz
Endeavour Ridge

- T-resistivity-H2 probe
- Microbial incubator
- McLane sampler
- Seismometers
- Still camera
- HDTV

Regional Circulation
- Nortek Aquadopp 2MHz ACM
- Seabird Microcat T & S
- High resolution pressure sensor
Over 80% of Earth’s volcanism is on ocean ridges

Juan de Fuca Ridge had 3 major extrusive events in 15 years
Microbial Incubator
The Autonomous Benthic Explorer (ABE)

AUV Odyssey

Jason2 ROV
ABE/JASON Surveys
NEPTUNE: Benefits to Canada

- Network Construction: contracts to suppliers, developers
- Network Operations: ongoing commercial innovation, industrial Innovation Cluster
- Job Creation: in technology, engineering, communications, research, support services, education/outreach, tourism
- Foster Training of HQP: several hundred graduate students, PDF’s, research assistants - highly competitive
- Long-term Database for Informed Socio-Economic Decisions
- Environmental Policy Issues: Seismic/tsunami hazards, gas hydrates, fish stocks cycles, offshore ocean circulation, regional climate models (El Nino), deeper water fisheries, pollution
Summary: Transformative Science

- Shelf to Deep Sea
- Cross-plate
- Remotely Operated
- Continuous, real-time data
- Four Dimensional
- Multi-disciplinary Linkages
- Integrative
- Coordinated Datasets
Summary: opportunities

- Transforming the ocean sciences
- Improved understanding of climate change
- Understanding role of gas hydrates
- Comprehending natural hazard processes: earthquakes, tsunamis, slope failures
- Sustaining commercial fisheries
- Understanding ecosystem dynamics
- Monitoring ocean pollution/acidification
- Industry: ocean technologies, services, data
- Info to public, decision-makers & politicians
- Educating the next generation
- International partnerships > global networks