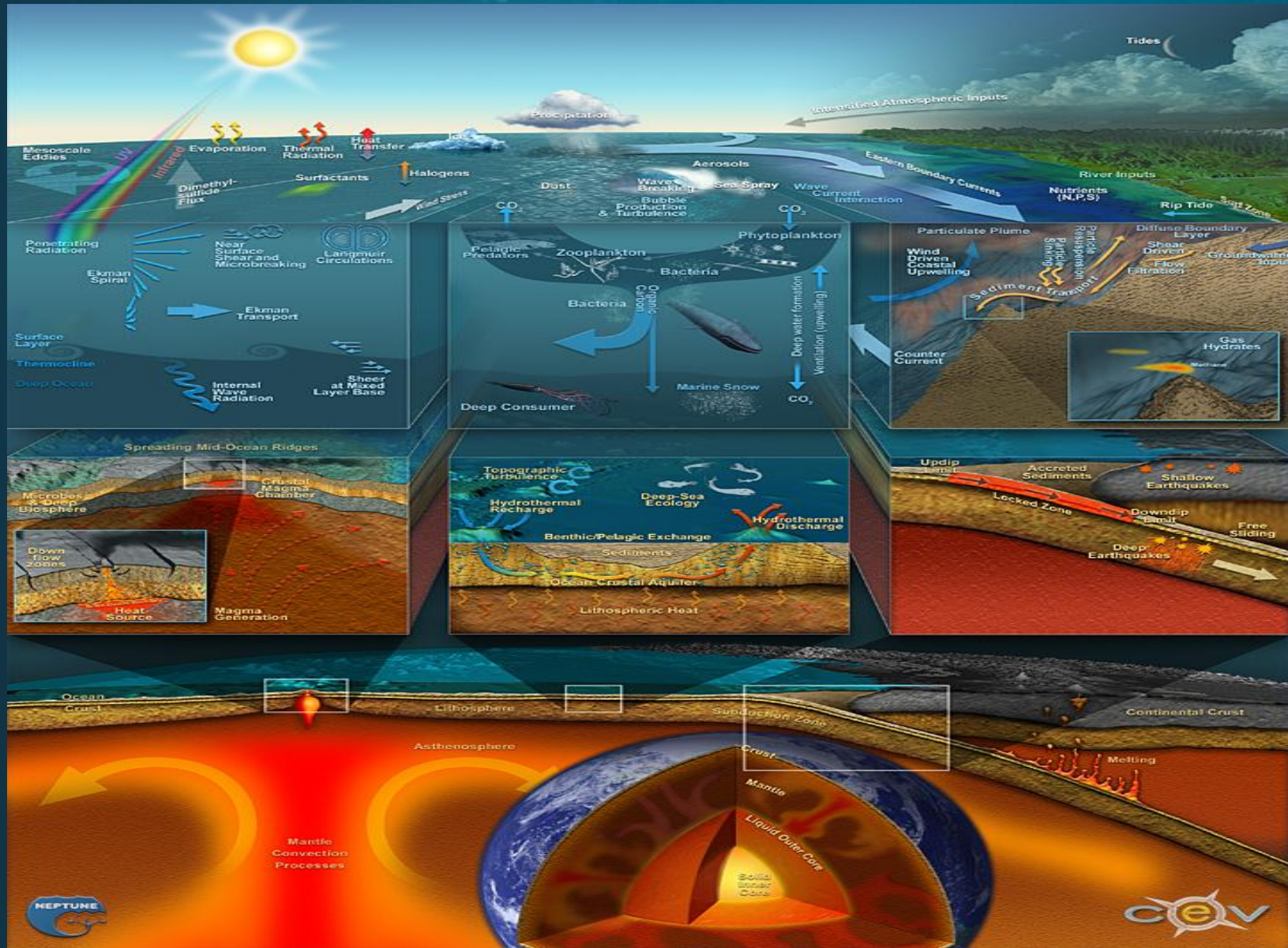


Data Acquisition from heterogeneous sensor networks

*The case of NEPTUNE Canada,
the world largest cabled ocean
observatory*

Benoit Pirene, Associate Director, Information Technology



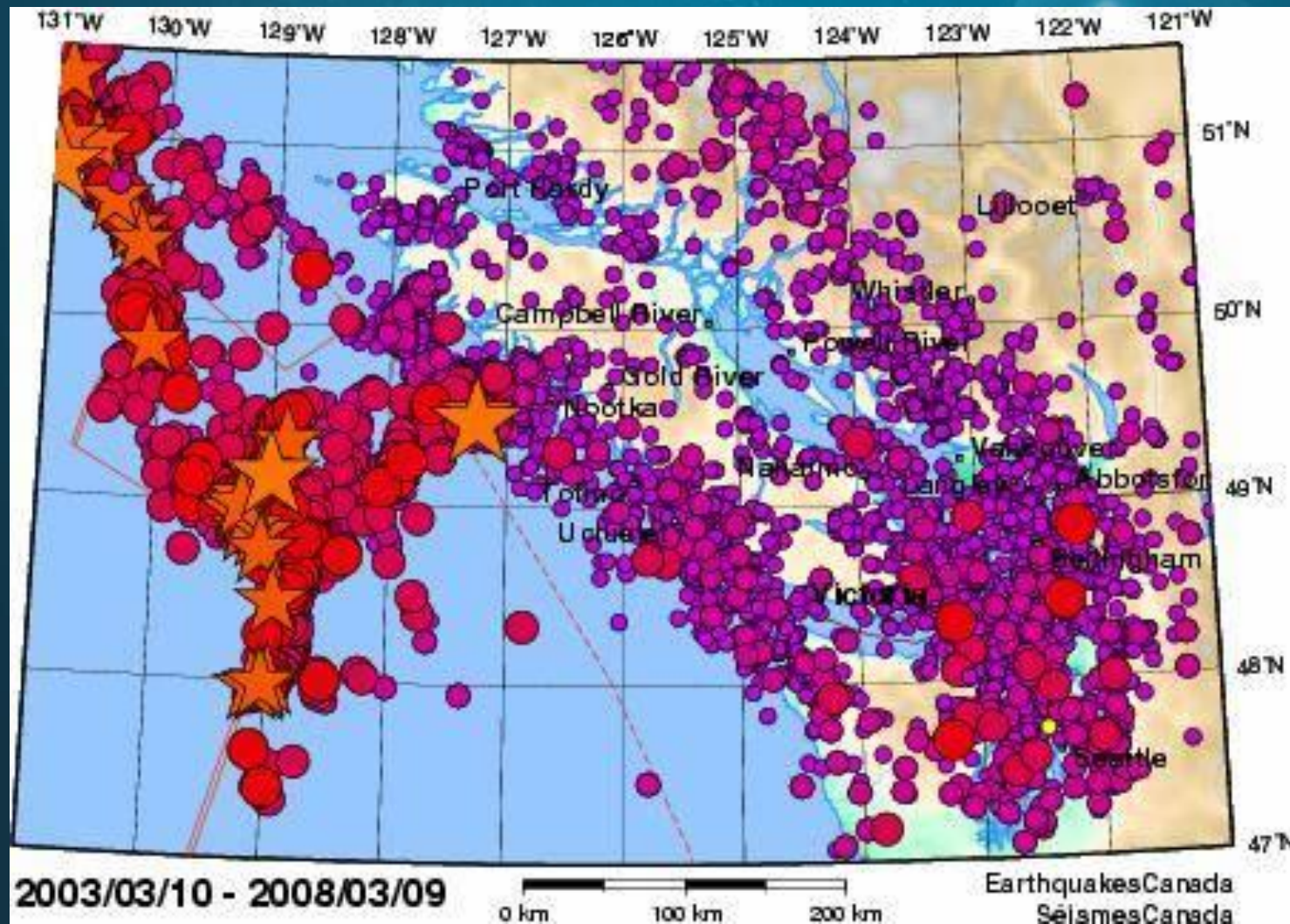


What is a Cabled Observatory like NEPTUNE Canada?

- Research infrastructure to contribute to many different science disciplines involved with the Ocean:
 - Plate tectonic processes and earthquake dynamics
 - Dynamic processes of fluid fluxes and gas hydrates in the sea bed
 - Regional ocean/climate dynamics and effects on marine biota
 - Deep-sea ecosystem dynamics
 - Engineering and computational research



Earthquakes in western Canada



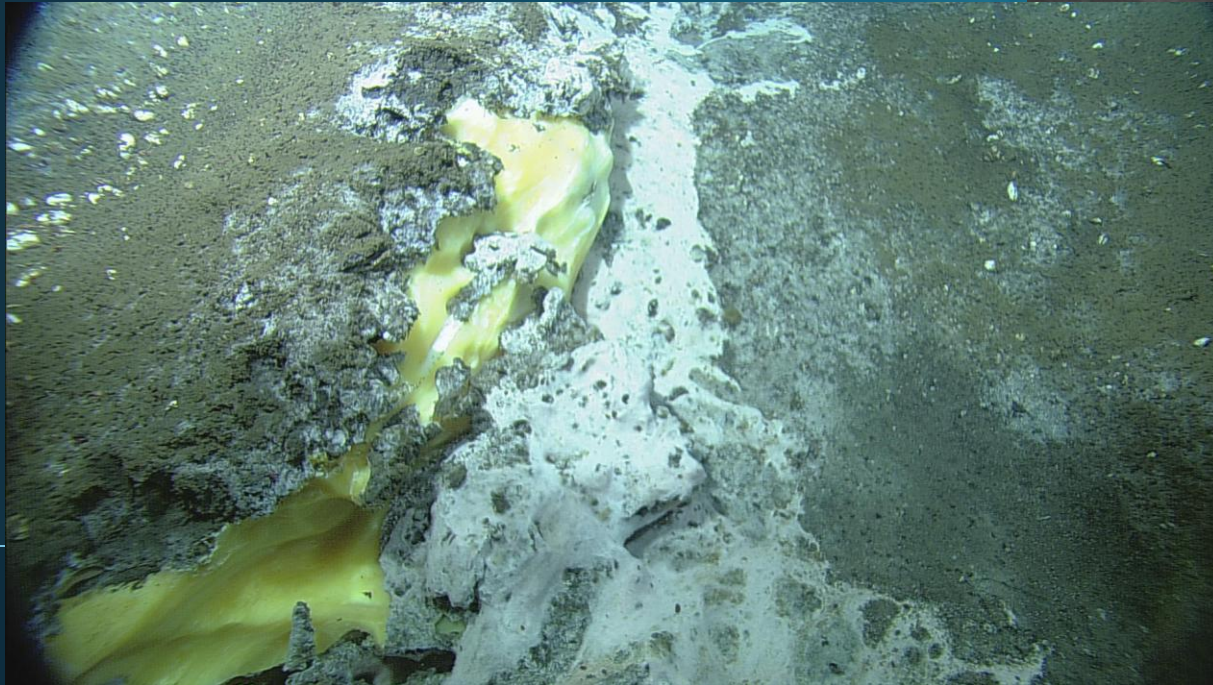
NEPTUNE Canada

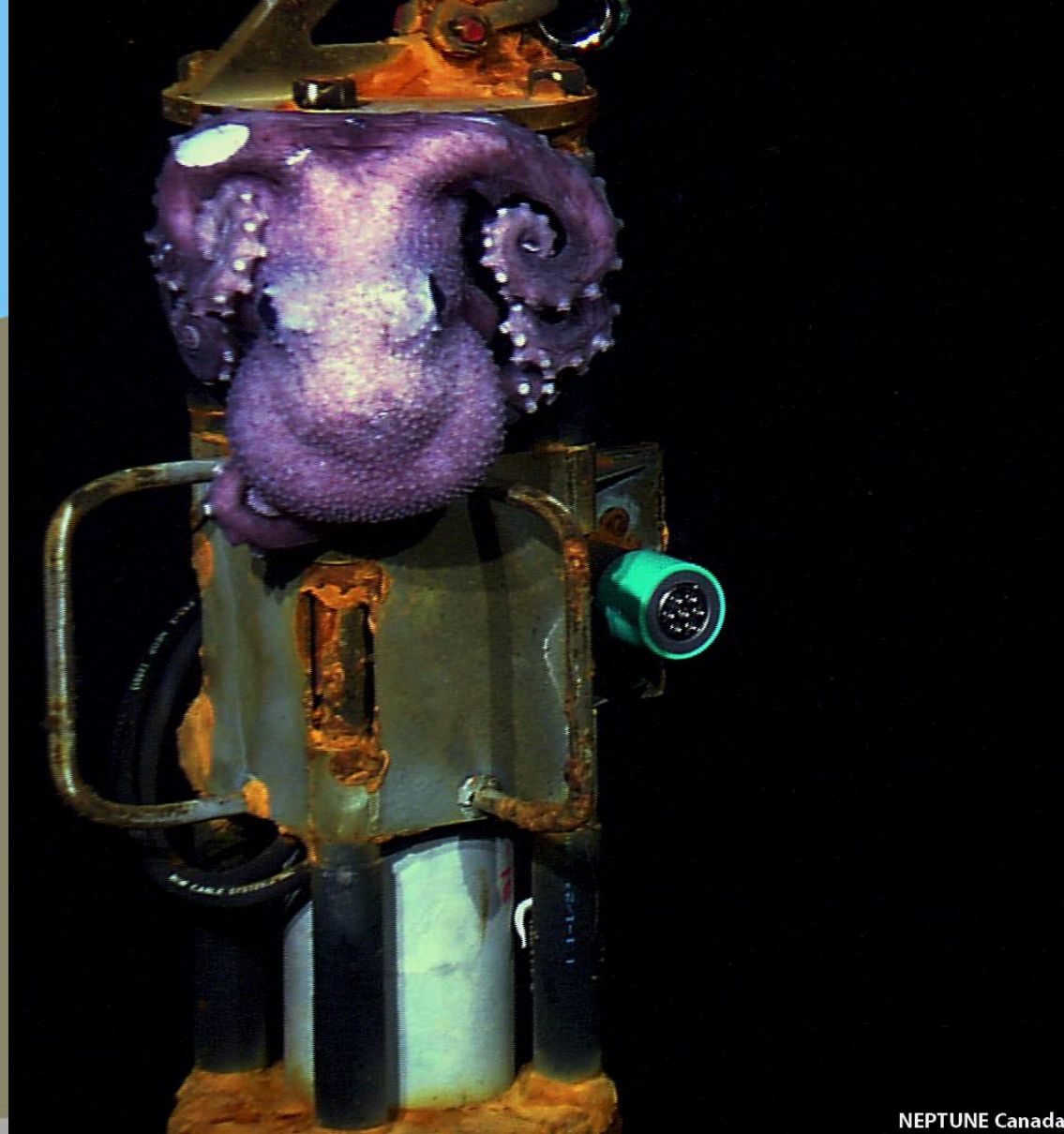
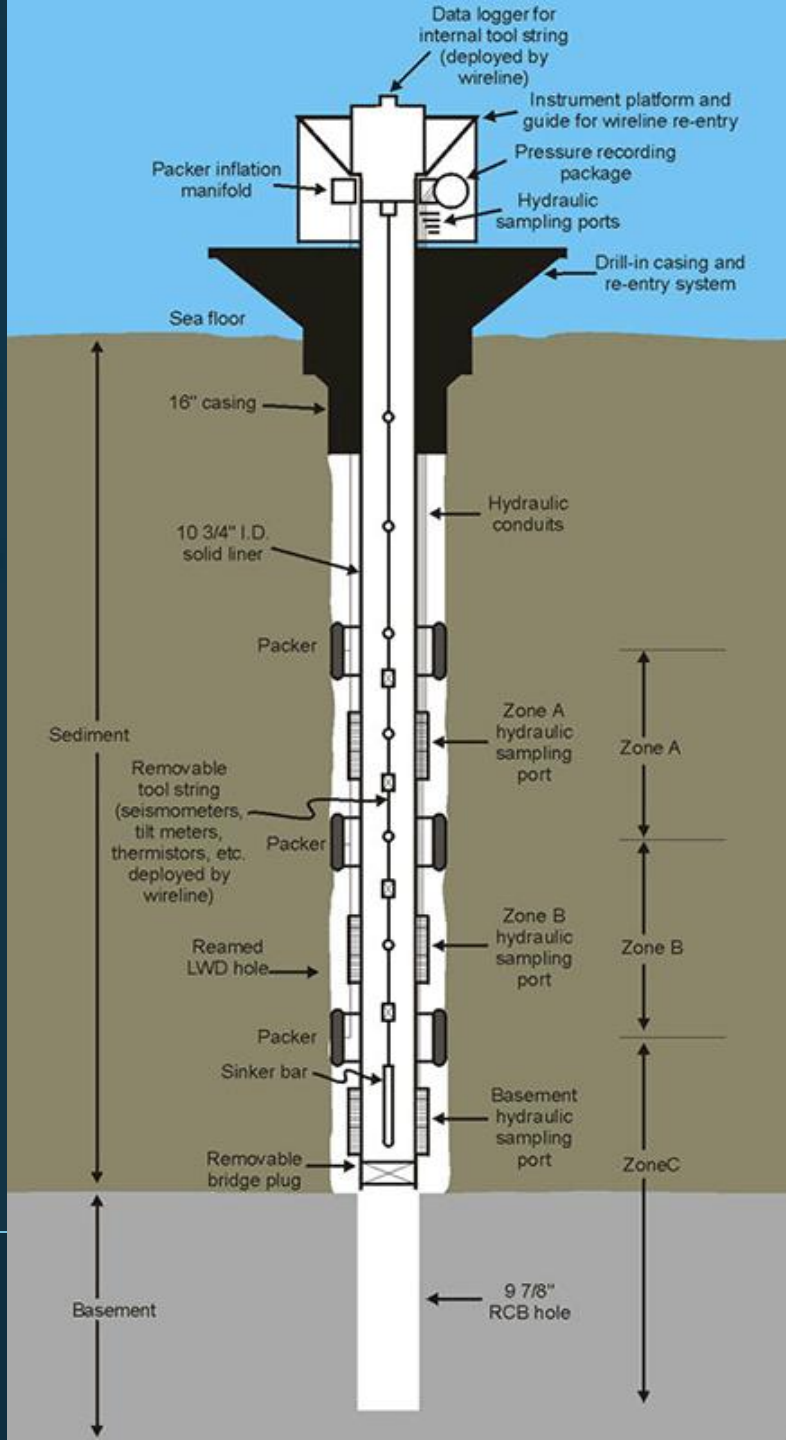
Recent earthquakes (most recent is shown in yellow) ●

● M < 2.0	● M ≥ 3.0	★ M ≥ 5.0	★ M ≥ 6.0
● M ≥ 2.0	● M ≥ 4.0		

METHANE HYDRATES

- Abundant in the NW Pacific
- Non-renewable energy source
- Unstable at surface

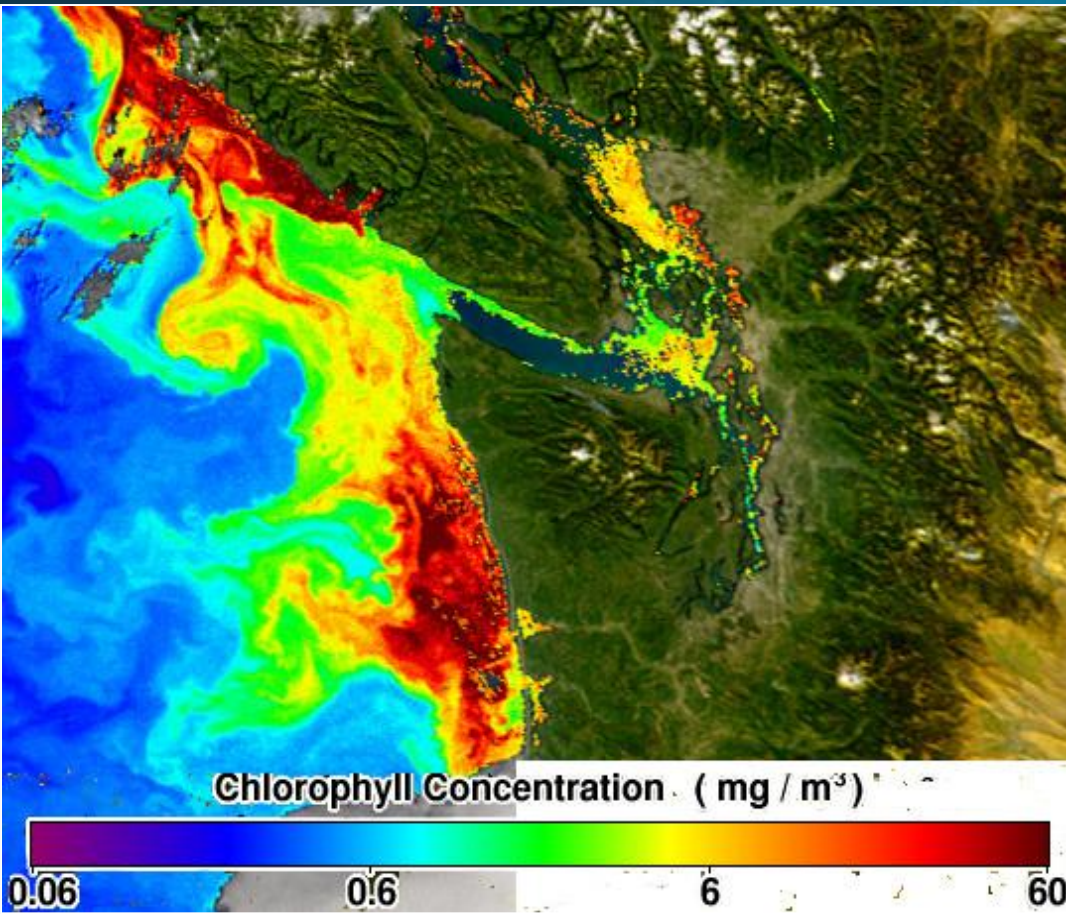




NEPTUNE Canada

ODP 1026 CORK

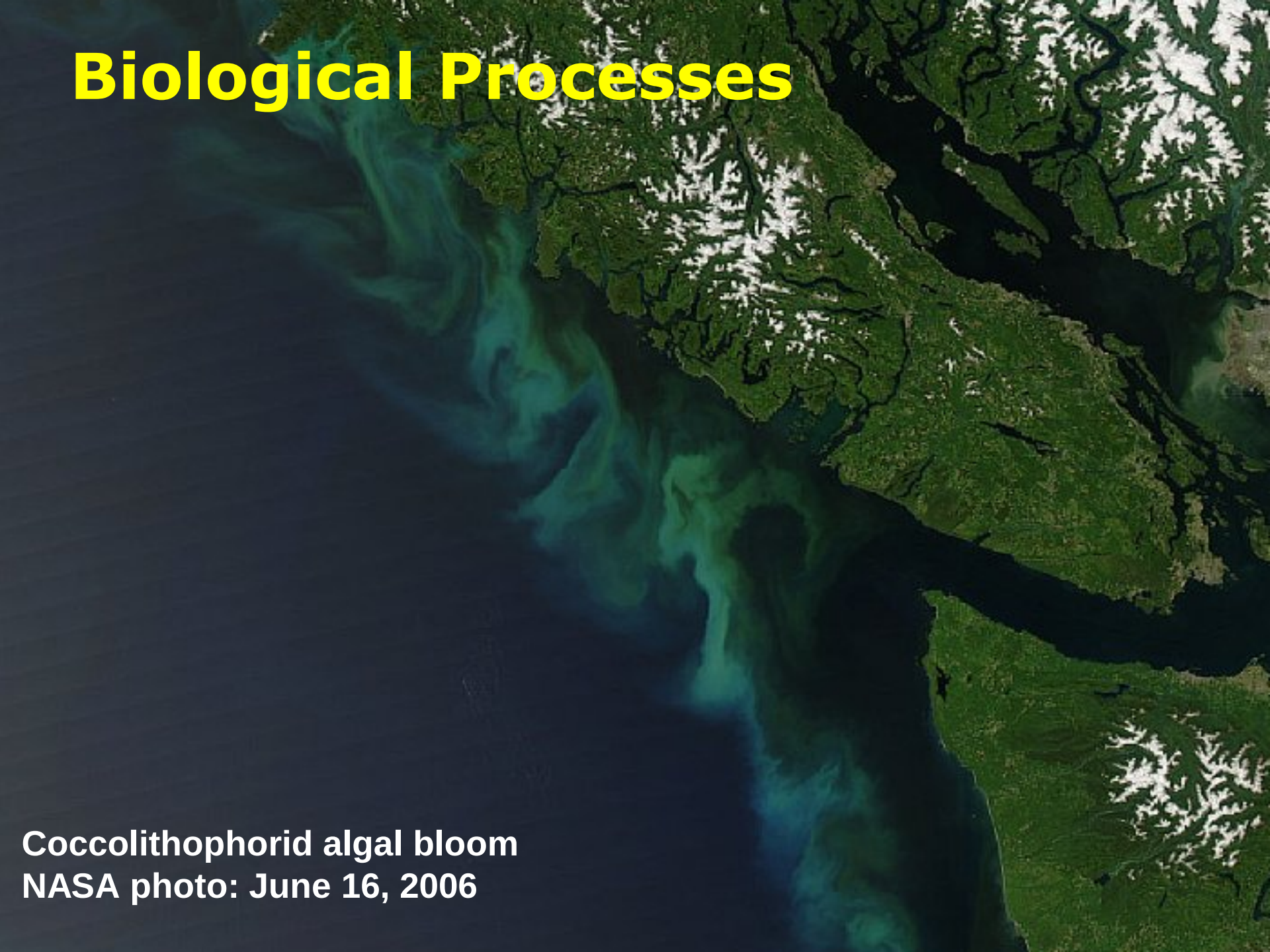
Ocean climate dynamics



- CTD
- Oxygen sensor
- Fluorometer
- Transmissometer
- Nitrate sensor
- CO_2 sensor
- Upwelling/downwelling radiometer
- Broadband hydrophone
- ADCP
- Bottom pressure sensor



Biological Processes

A satellite photograph showing a large, swirling, greenish-brown algal bloom in the ocean. The bloom is located off the coast of Alaska, with the rugged coastline and snow-capped mountains visible in the upper right. The water surrounding the bloom is a deep blue.

Coccothiorid algal bloom
NASA photo: June 16, 2006

Tracking marine mammals

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



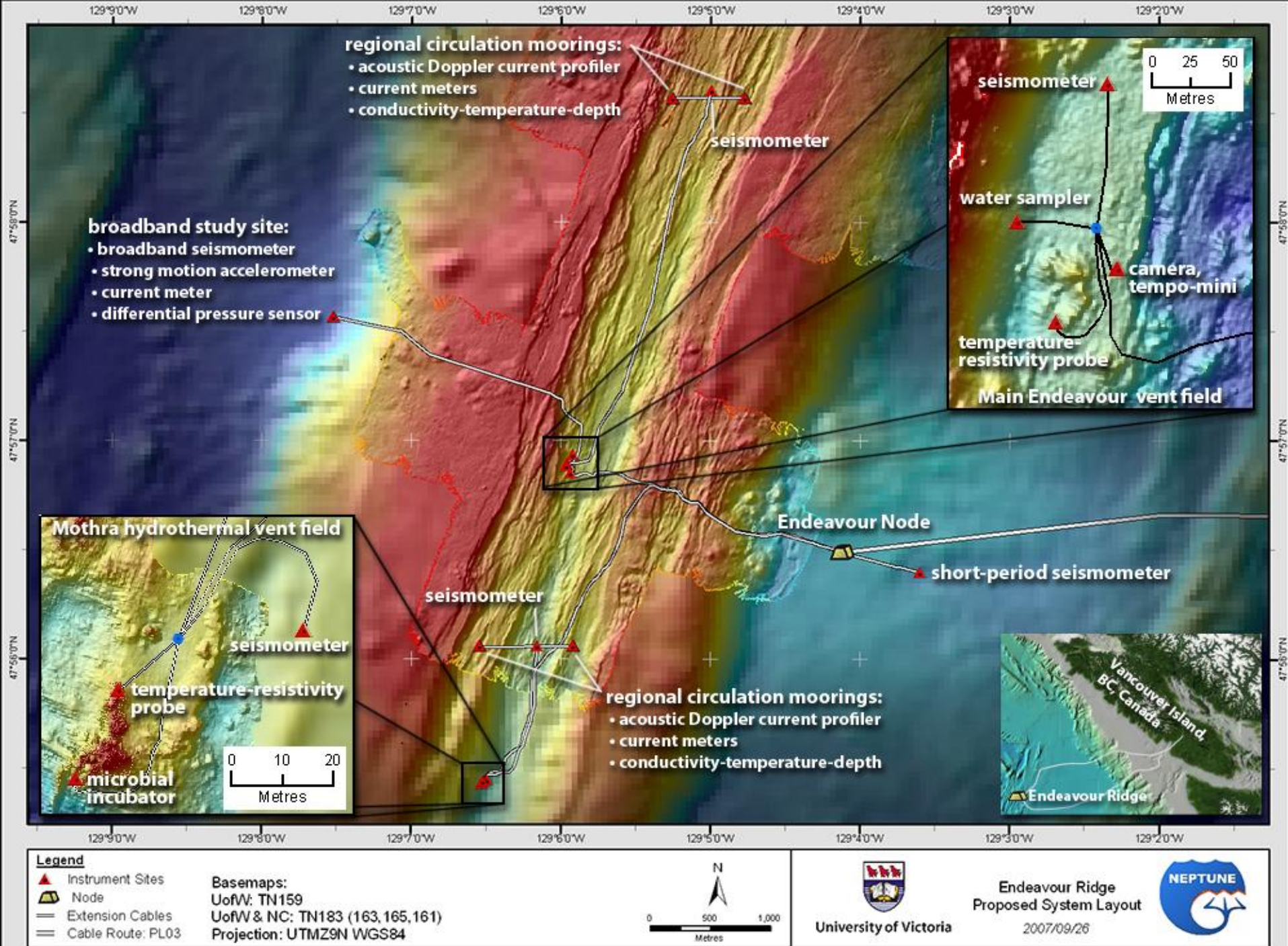
- Killer whales 100 Hz to 20 kHz
- Great whales 10 to 1000Hz



NEPTUNE Canada

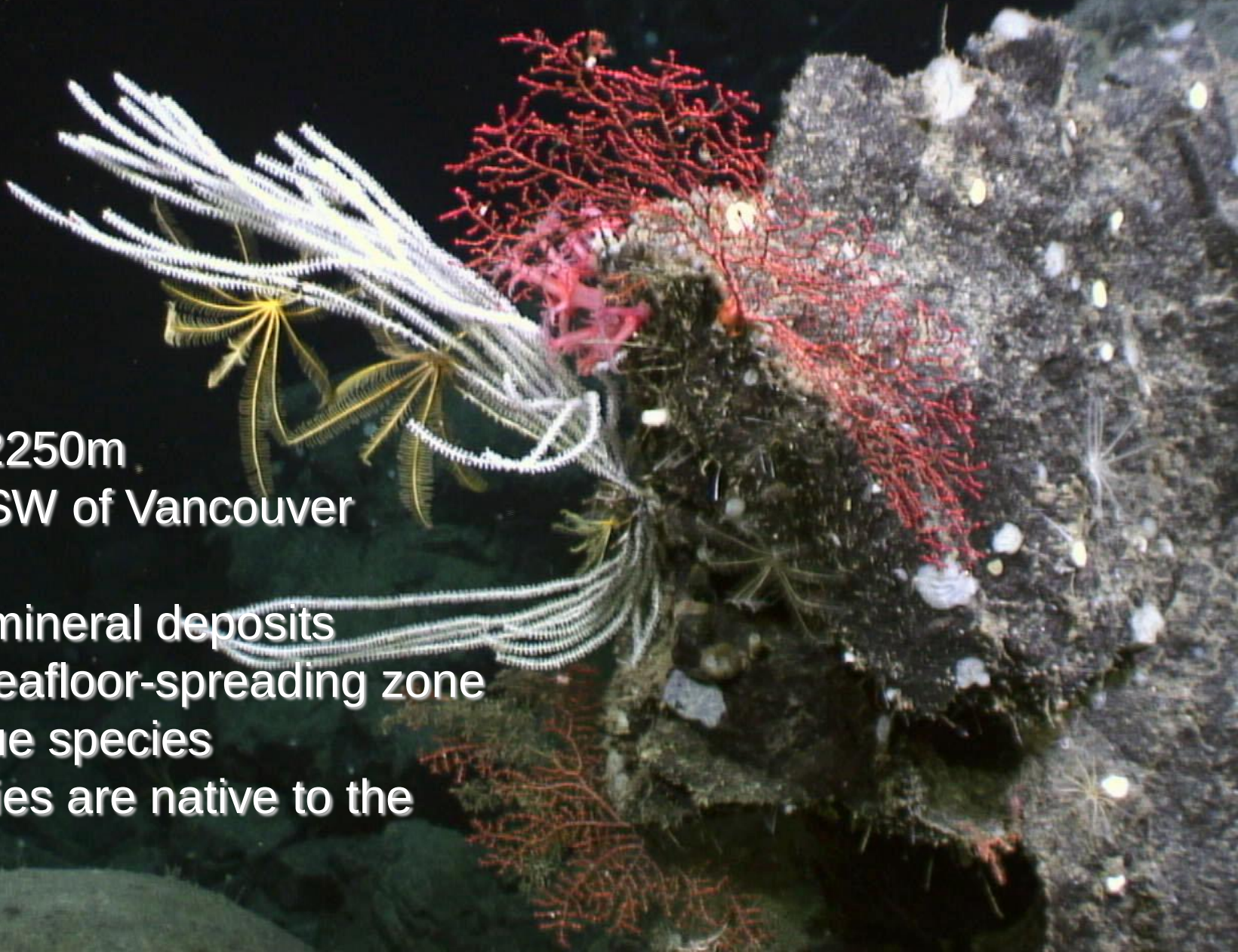


NEPTUNE Canada

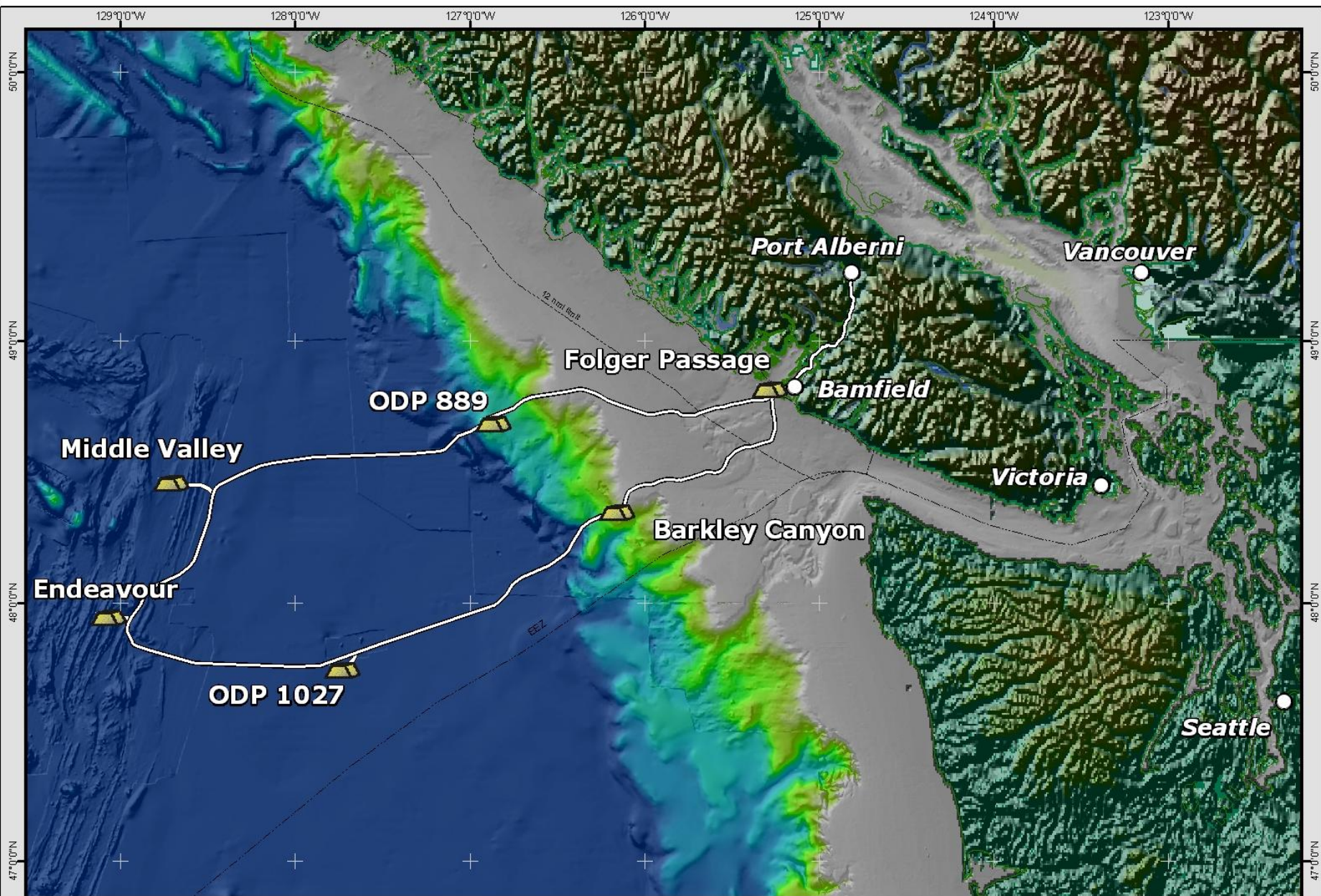


ENDEAVOUR HOT VENTS - MPA

- Depth: 2250m
- 250km SW of Vancouver Island
- Rich in mineral deposits
- Active seafloor-spreading zone
- 12 unique species
- 60 species are native to the area







Legend

-  Science Node
-  Cable Route PSR12

Basemaps:
USGS Open File No. 99-369
Projection: Mercator, LTS 48°



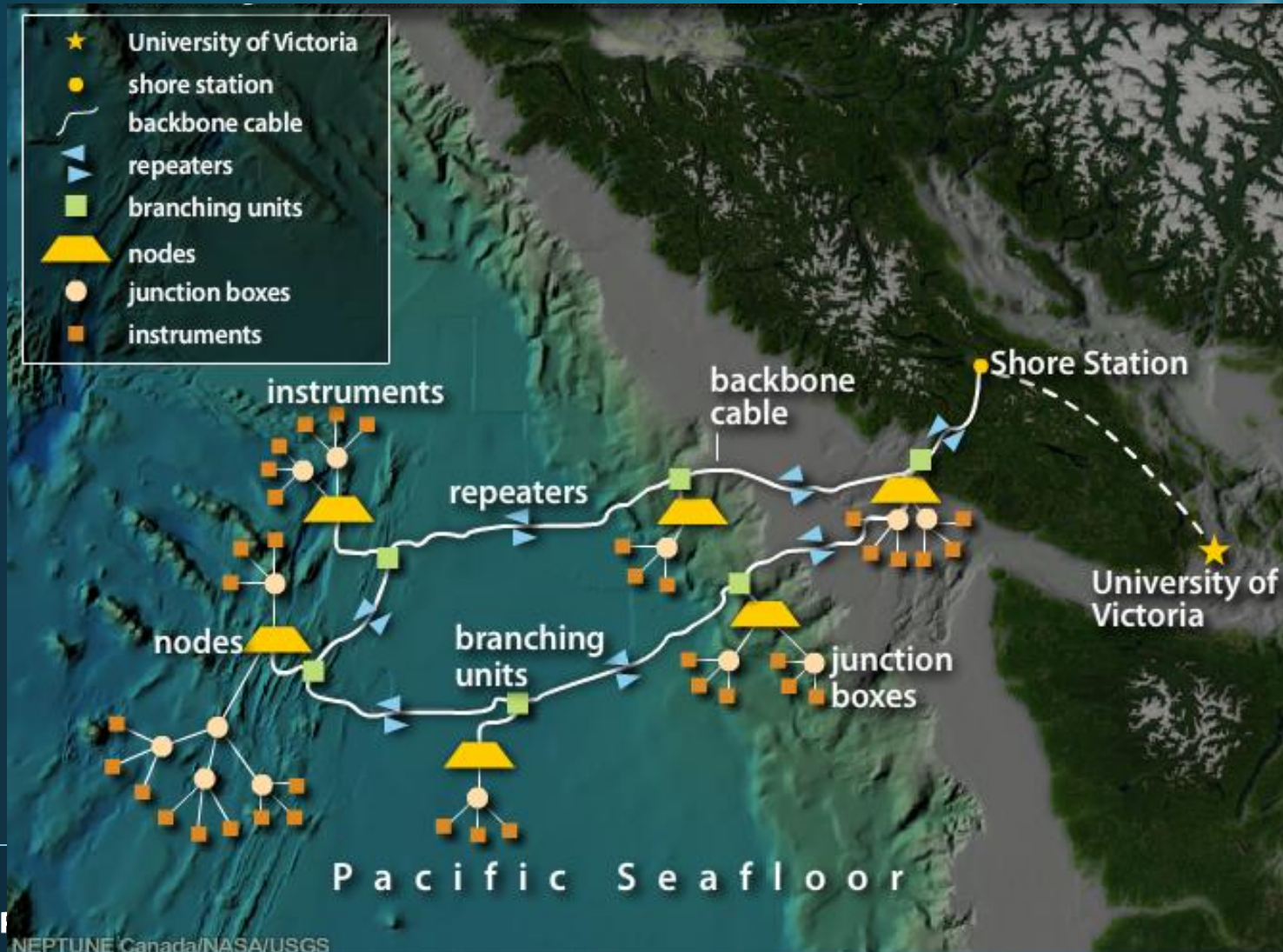
University of Victoria

NEPTUNE Canada Observatory
Proposed System Layout

2007/05/14

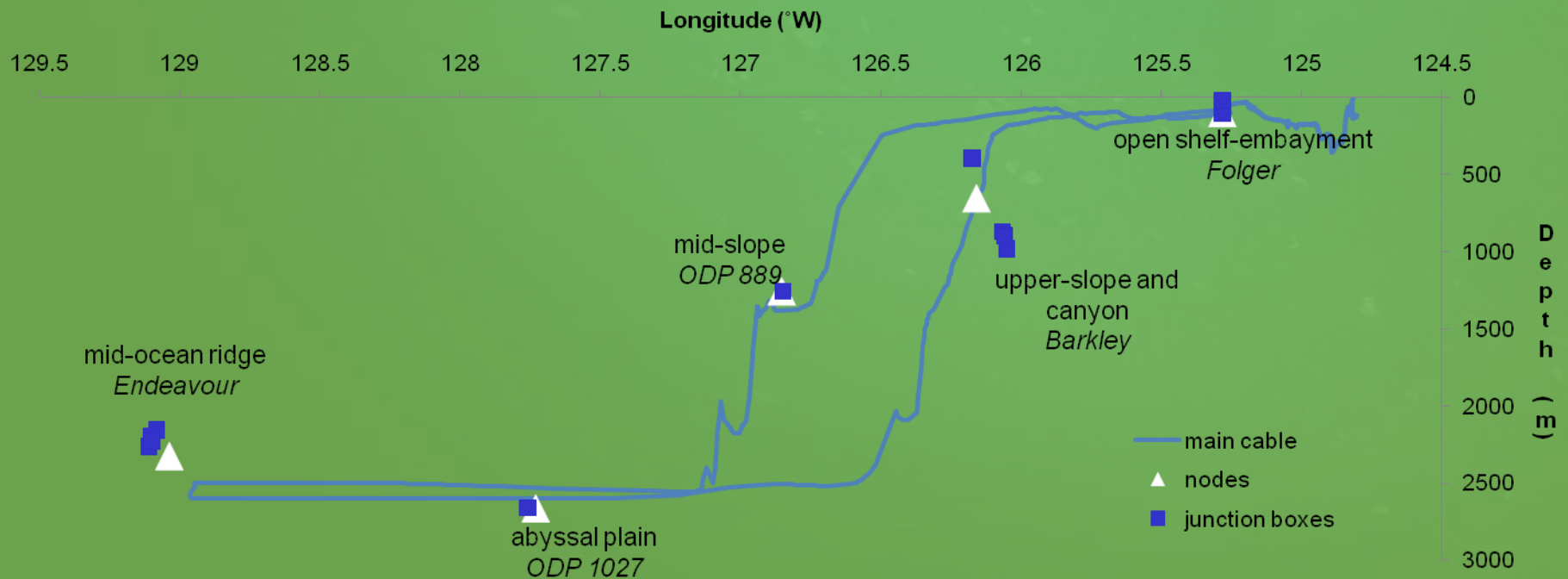


What is NEPTUNE Canada



NEPTUNE

Broad Range of Ocean Environments



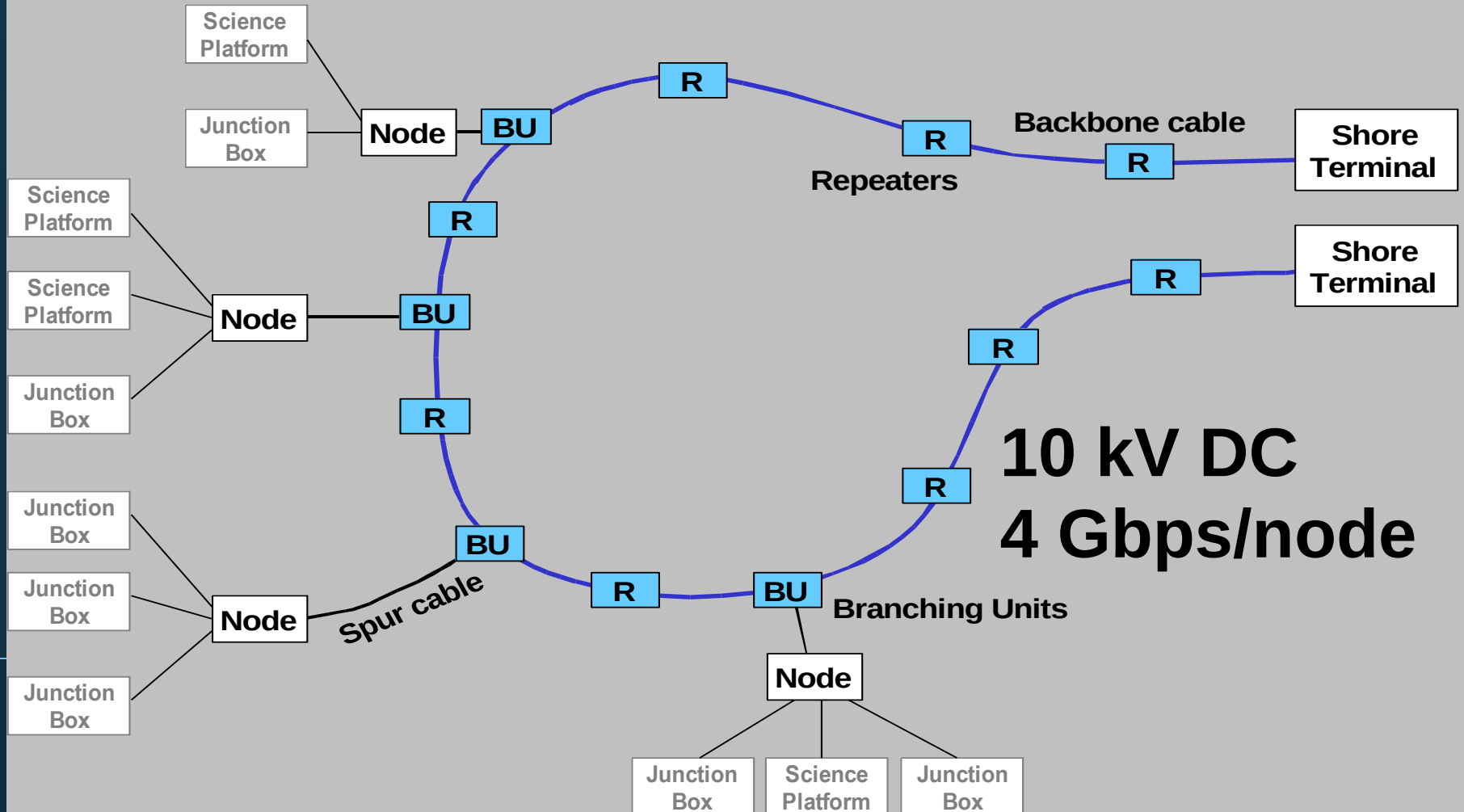
NEPTUNE Canada: What is it?

- Gigabits of bandwidth
- Kilowatts of power
- Precision timing
- Hundreds, perhaps thousands, of attached devices
- 3000m water depth rating
- 25-year design life
- Resilient network, moderate operating costs
- Over 70TB/yr data flow initially
- Expandable and extendable: 5→10 nodes



Subsea: Backbone

Generalized Observatory Configuration



Subsea: Nodes (AL)

Science Node
in TRF

Trawl Resistant Frame (TRF)



Science Node Float Assembly



Science Node



Node Frame



Medium Voltage Power
Converter Assembly



Low Voltage Power / Comms Assembly

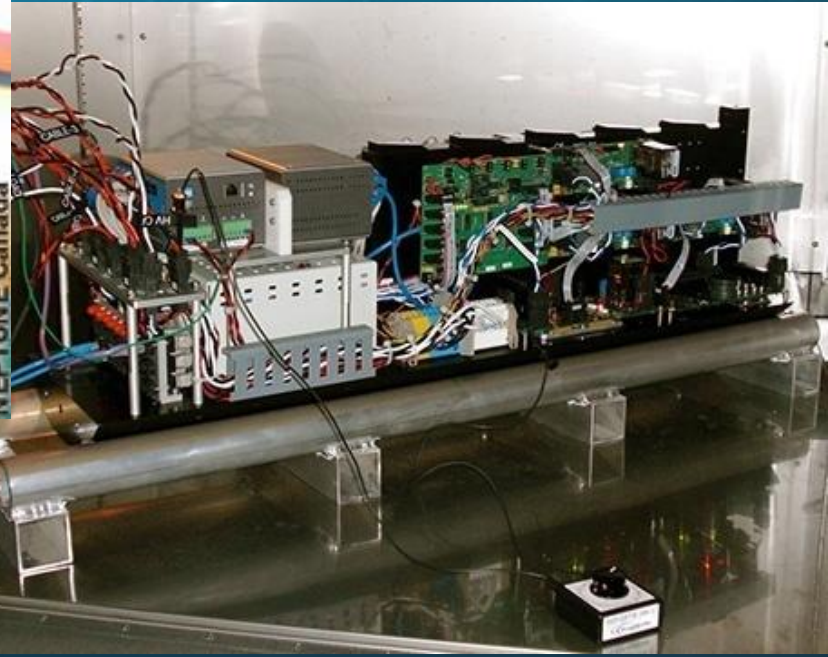


10kV DC -> 400V DC
4x2 Gbps Ethernet



NEPTUNE Canada

Subsea: Junction Box (OWI)



400V DC -> 48/24/15V DC



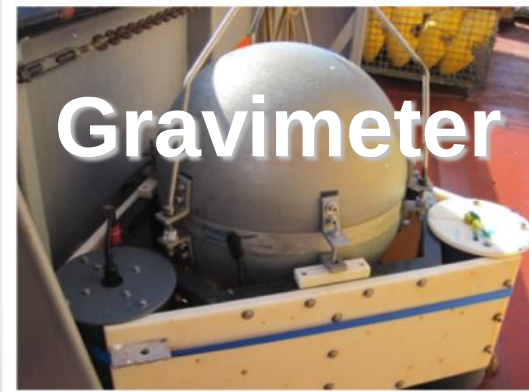
NEPTUNE Canada

Subsea: Instruments



Hydrophones

For listening to the Earth,
monitoring seismic activity,
and
observing pore
pressure...



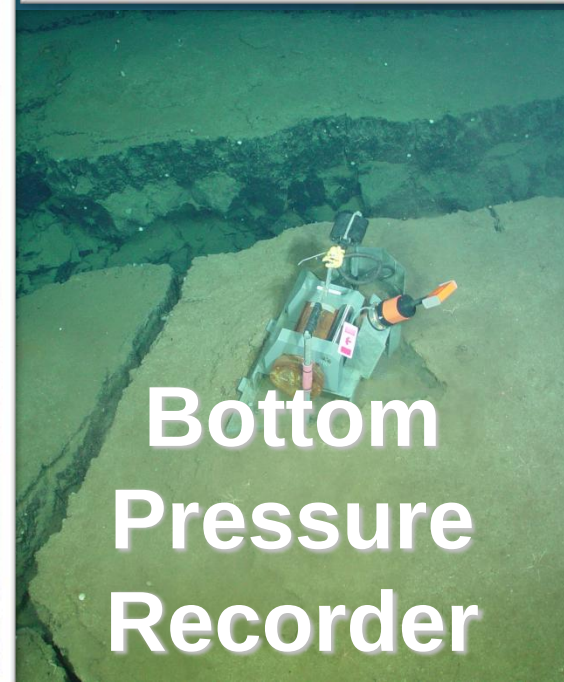
Gravimeter



Seismometer

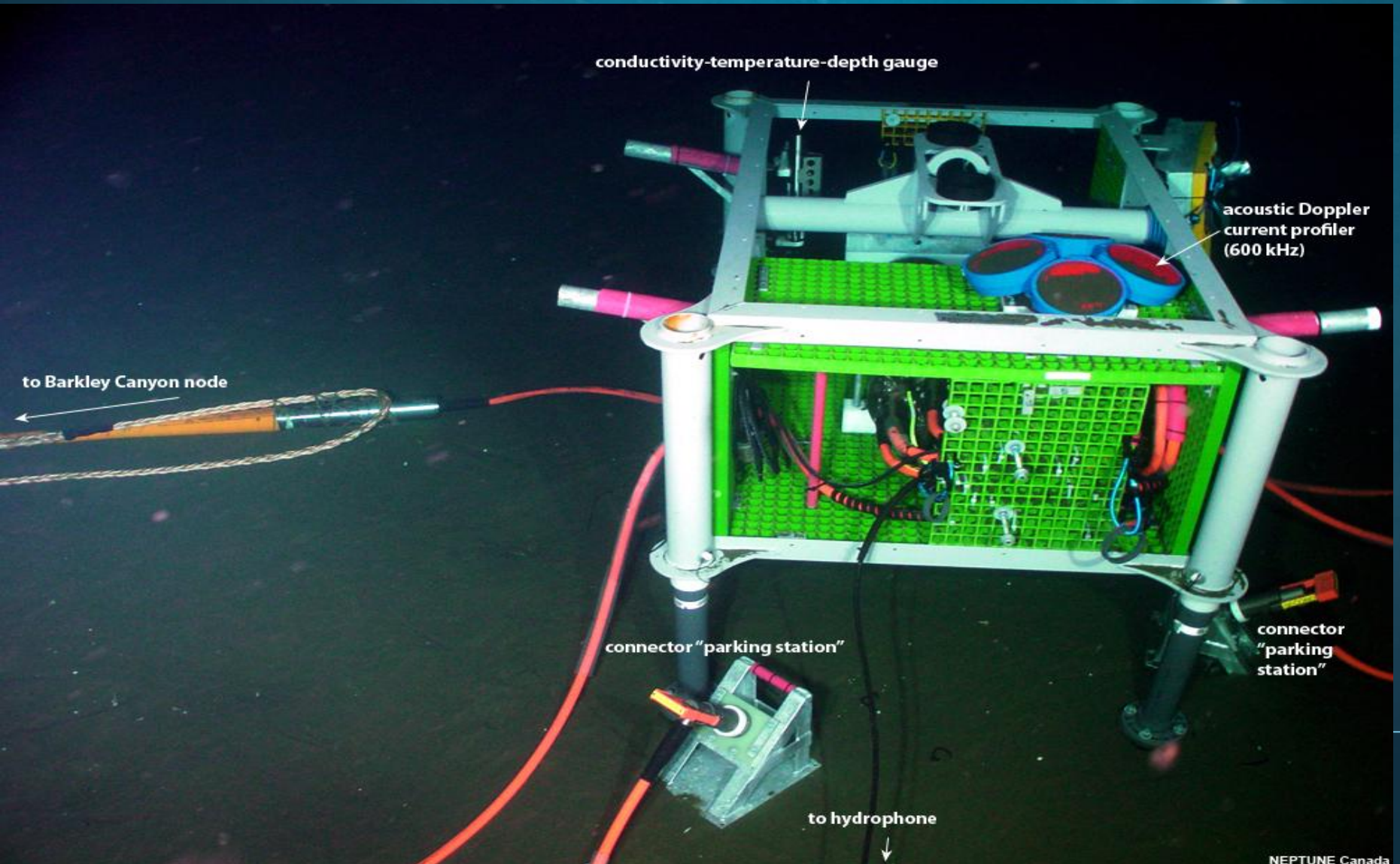


Peizometer



Bottom Pressure Recorder

Subsea: Instruments



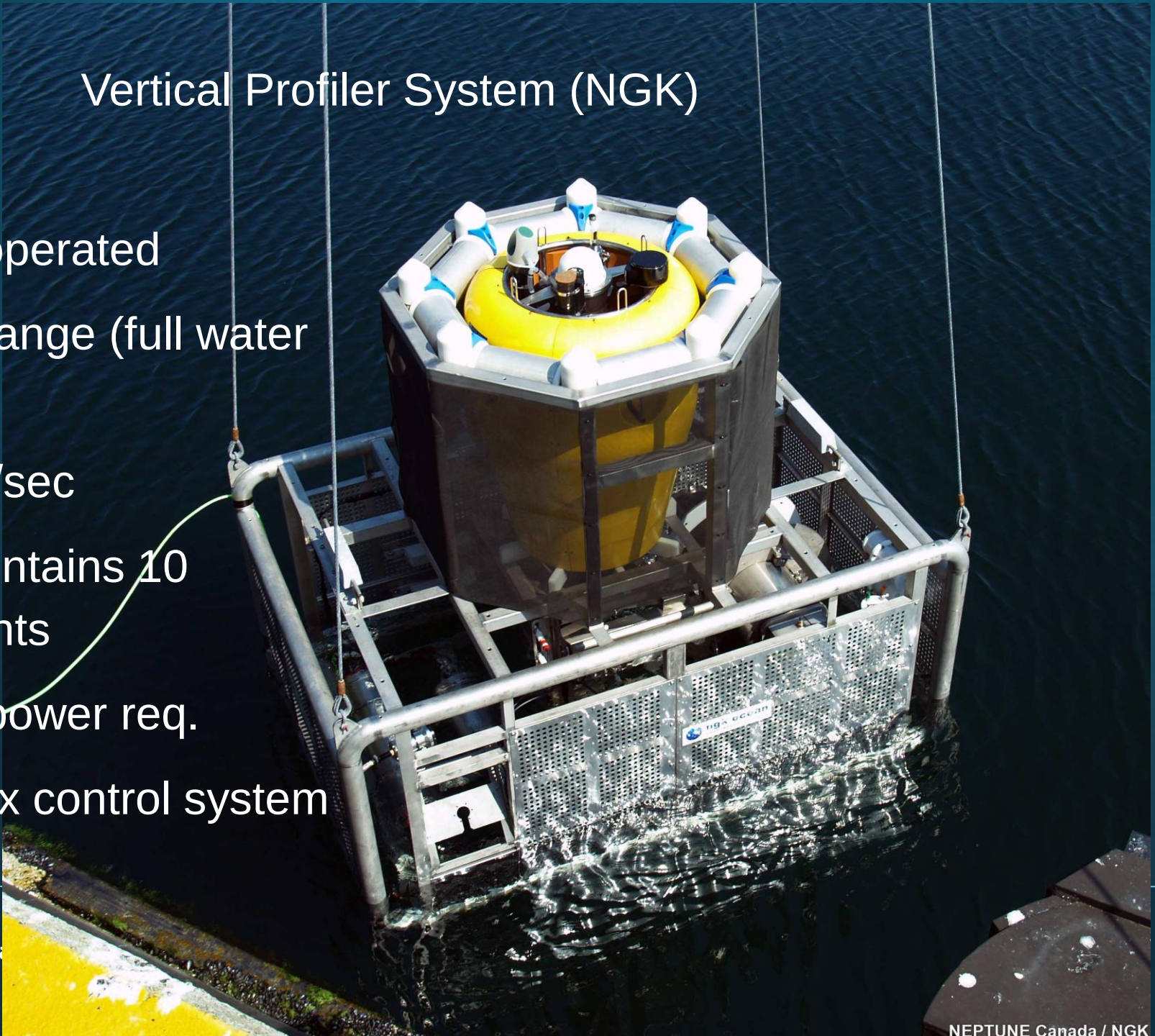
Subsea: Instruments

Remotely operated vehicles such as “Wally” on the NEPTUNE Canada array use temperature probes, methane sensors, oxygen profilers, and a camera to better understand the hydrate fields



Vertical Profiler System (NGK)

- Winch operated
- 400 m range (full water column)
- ~20 cm/sec
- Float contains 10 instruments
- ~3 kW power req.
- Complex control system



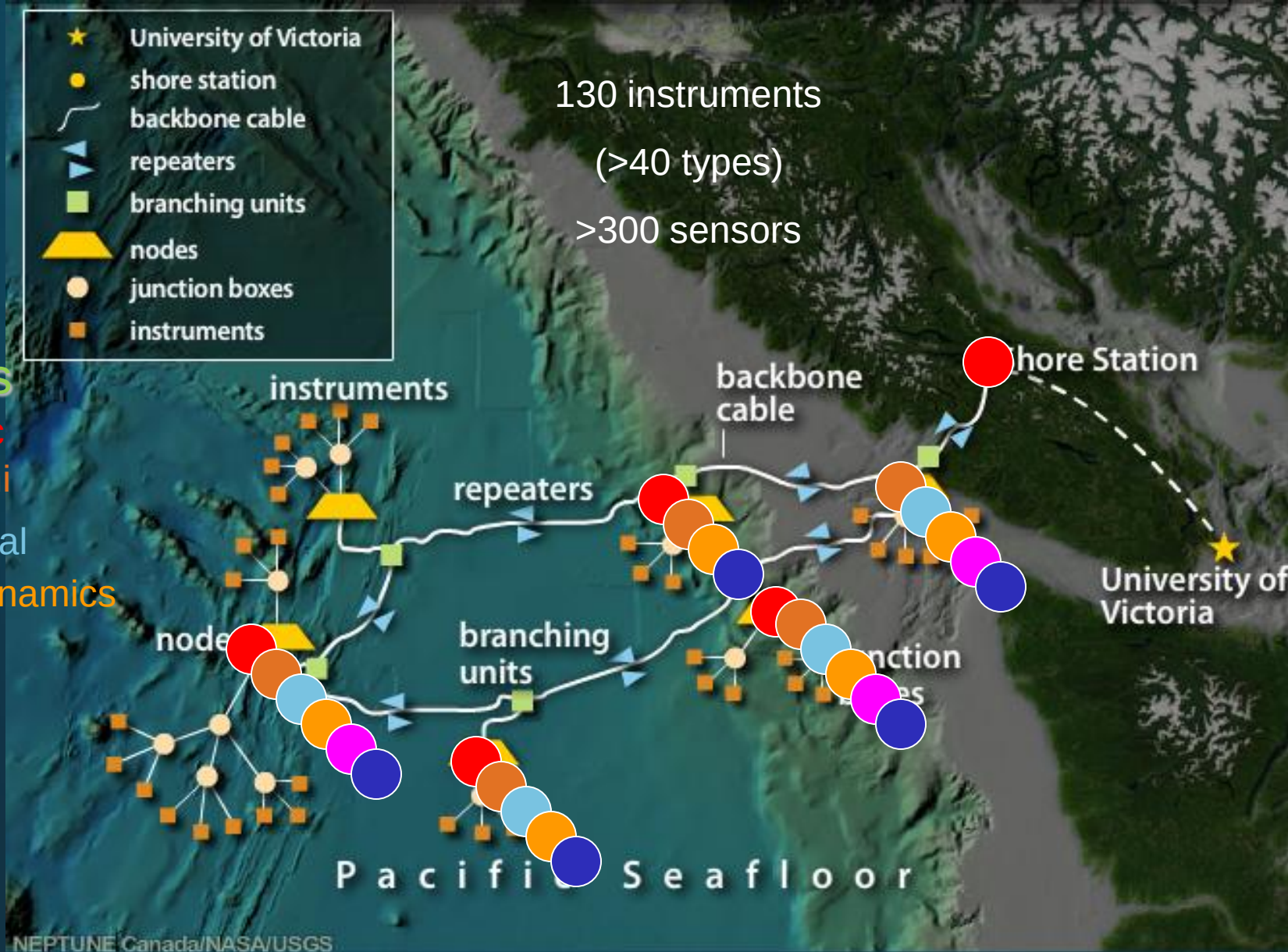
NEPTUNE C



130 instruments
(>40 types)
>300 sensors

Networks

seismic
tsunami
chemical
fluid dynamics
visual
audio



NEPTUNE Canada

Power and internet to the deep sea
10 kV, 4 Gbps/node



NEPTUNE Canada

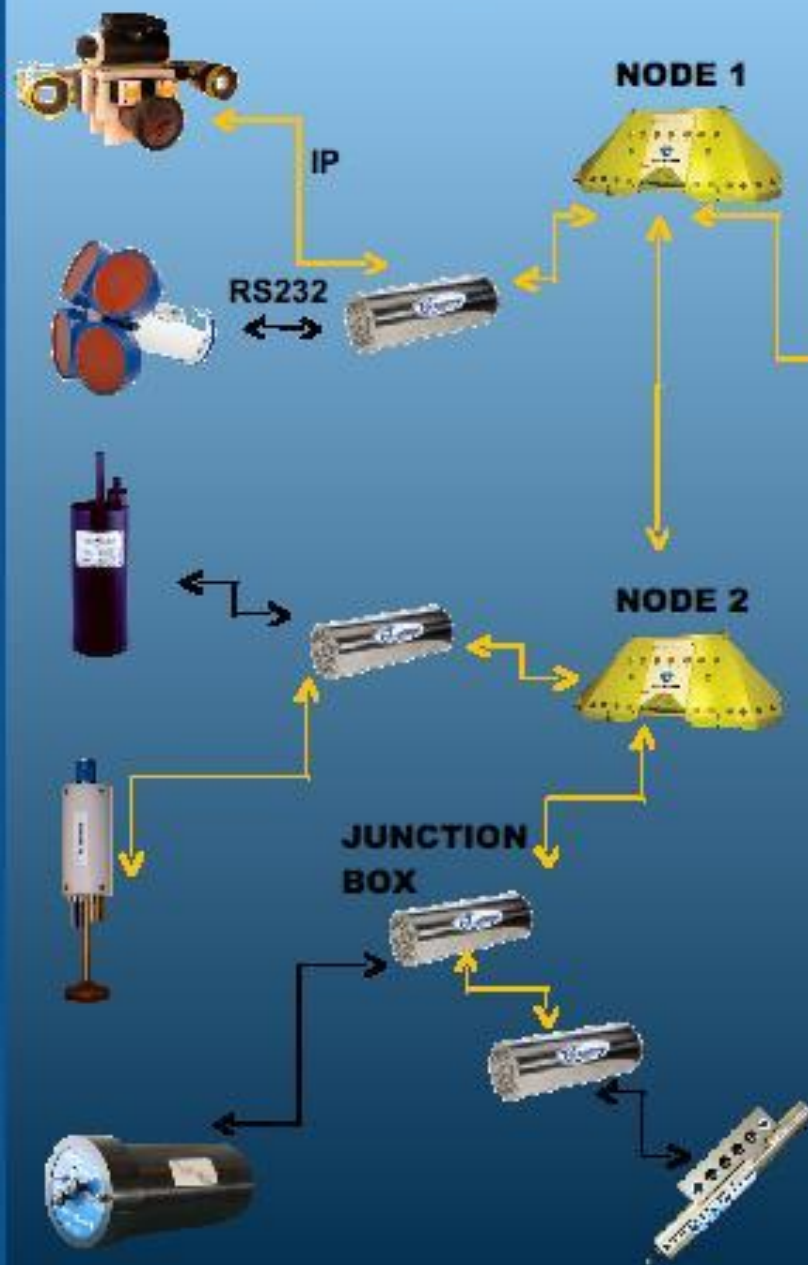
Transforming Ocean Science



NEPTUNE Canada

NEPTUNE Canada Science & Data Workshop, 12-14 April 2010

WET PLANT



SHORE STATION



- Buffering
- Routing
- Instrument Commanding

OPERATION CENTRE



CANARIE LINKS



- Database
- File Storage
- Web Server
- Firewall
- Resource Scheduling



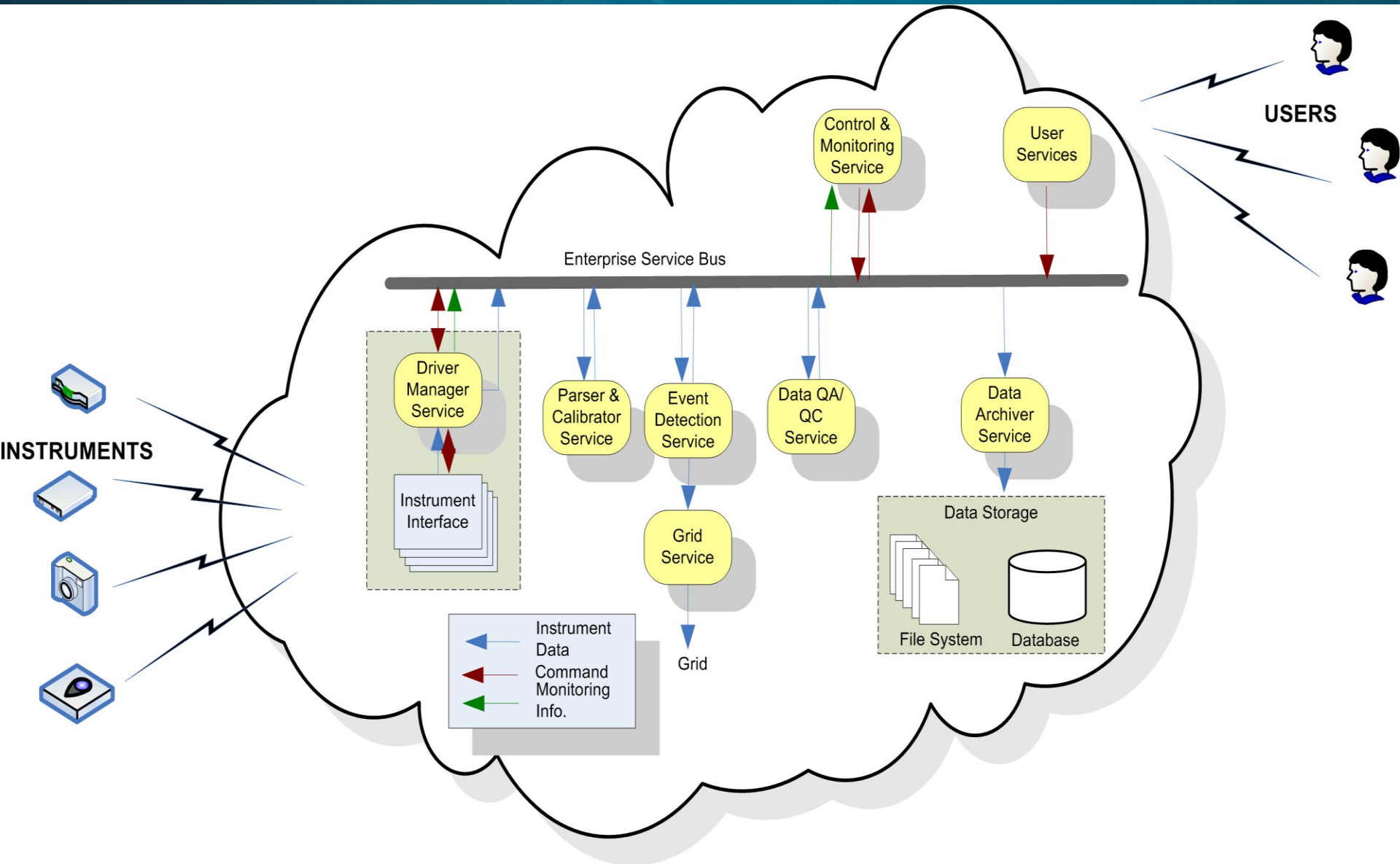
SCIENTISTS



PUBLIC

- Web
- Web Services
- Forms
- SQL
- Smart Phone Applications
- Streaming Video & Sound



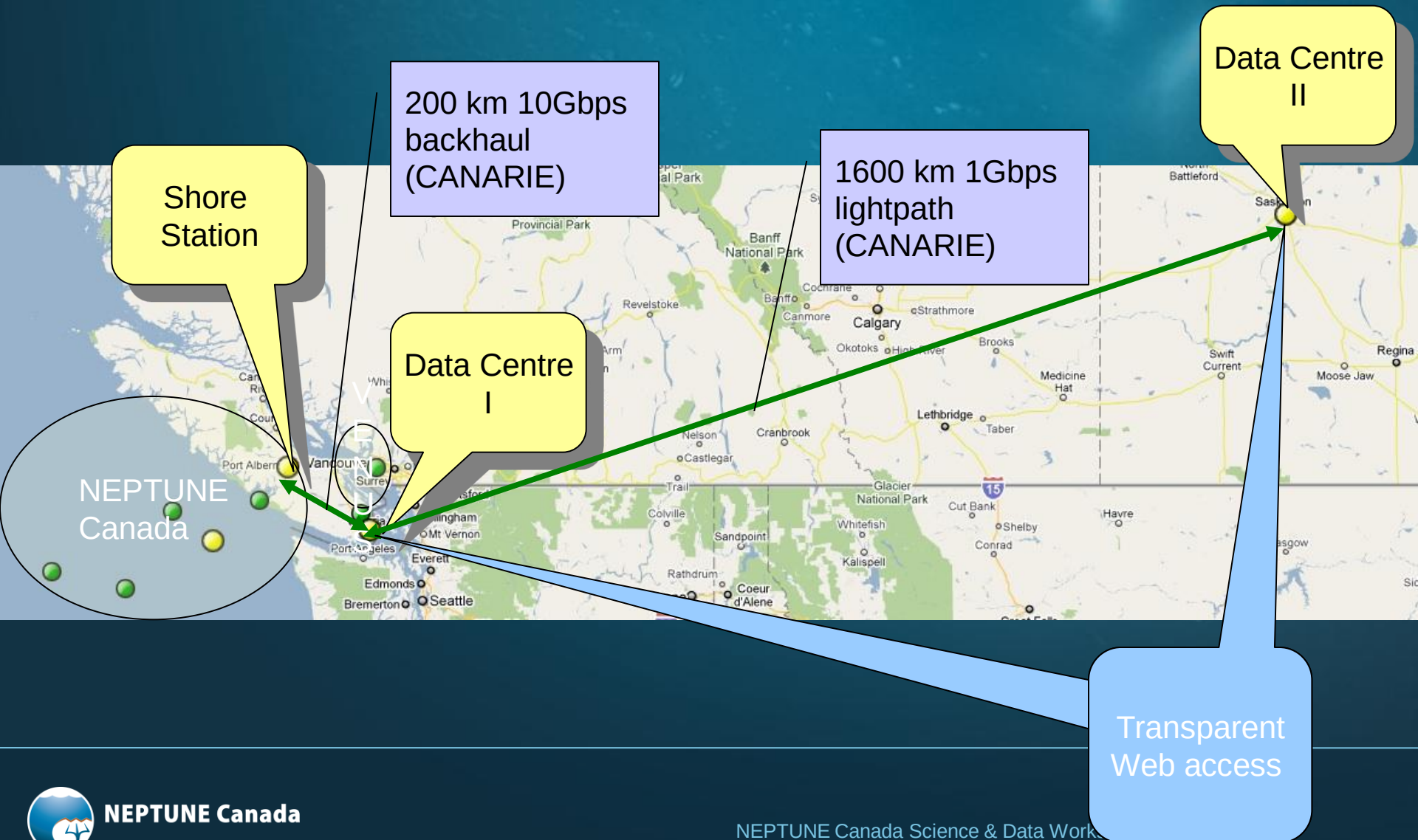


NEPTUNE Canada
Transforming Ocean Science



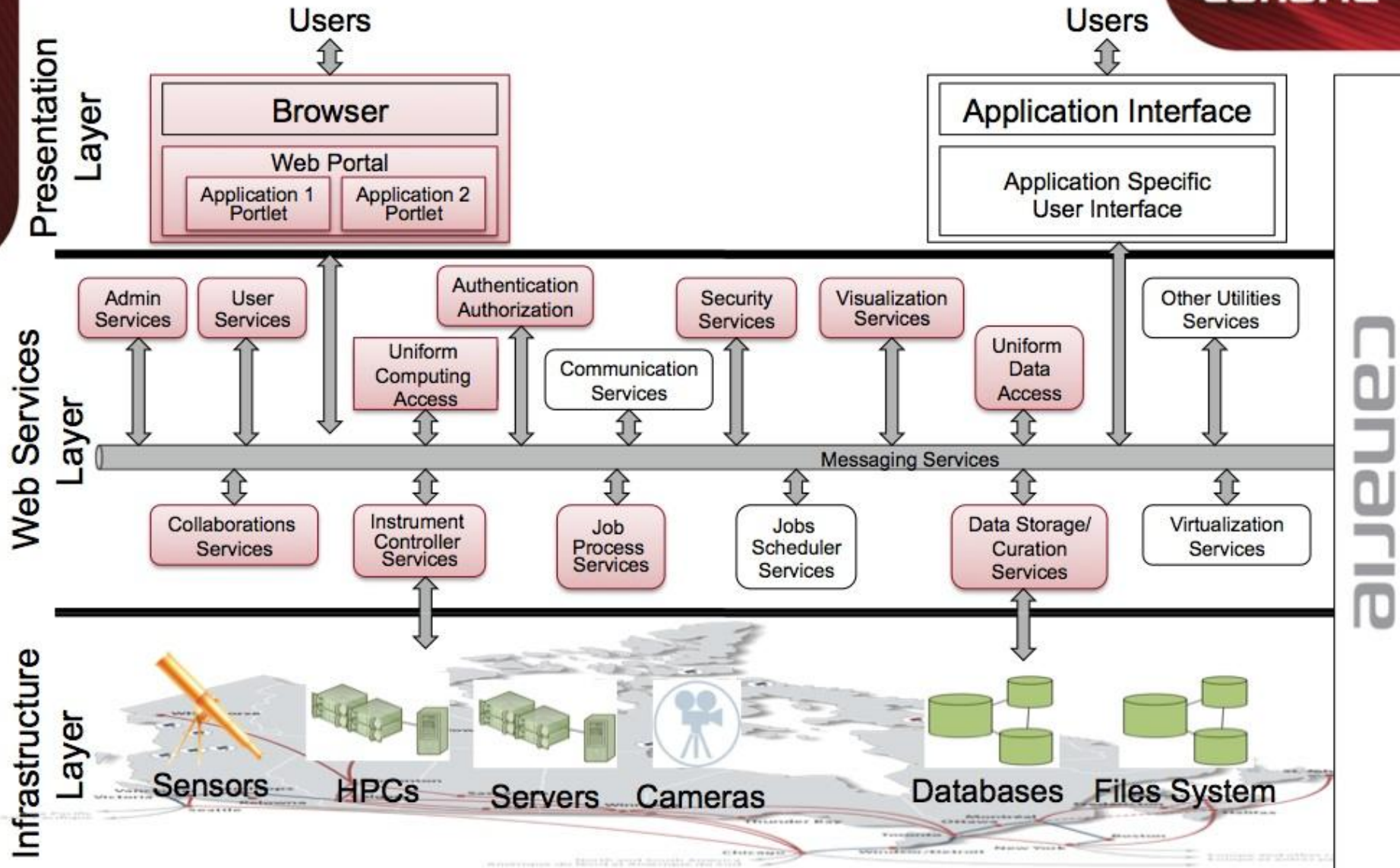
OCEAN NETWORKS CANADA
A University of Victoria Initiative

Land-based Infrastructure



DMAS: Cyber-Infrastructure Block Diagram

canarie





NEPTUNE Canada

Transforming Ocean Science



NEPTUNE Canada

NEPTUNE Canada Science & Data Workshop, 12-14 April 2010

Data Management mandate:

- Extension of the Internet under the Ocean
- Capture data from many different types of sensors
- Interact with underwater instrumentation (e.g., cameras)
- Precision time
- Keep data + metadata for 25 years
- Provide search, visualization, data products to many users
- Allow for X-correlation between data from various sensors
- Detect and react to events

Initial challenges

- Instrumentation selected by scientist, of a legacy nature, off-the-shelf
- No standard: all instruments are different (connectors, data transmission protocol, control protocol, data acquisition, meta data, ...)
- Instrumentation often not conceived for long term deployment, not expected to be in a powered environment, and in particular not expected to be shared by many users
- New standards are emerging now, such as SensorML...

Extension of the Internet under the ocean

Device Id: **20116** Device Name: **Aanderaa optode 3830**

General | **Sensor** | **Ip** | **Electrical Rating** | **Data Rating** | **Nameplate** | **Port** | **Physical Characteristic**

IP Id	DNS Name	IP Address	IP Port	Date From	Date To	IP Type
1146		10.40.10.132	4005	02-Apr-2008	01-Nov-2008	Instrument
1238	optode.deep.folger.neptune	10.136.136.131	4004	05-Mar-2009		Instrument

Add IP

Capture data from many instruments

Video Server, Camera System, Camera Laser, Camera Pan And Tilt, Particle Analyzer, Orientation, ACM (acoustic current meter), ADCP (acoustic doppler current profiler), BPR (bottom pressure recorder), CO2 sensor, CTD (Conductivity Temperature Depth), Nitrate sensor, T resistivity probe, Camera, 3D, Camera, rotary, Camera, still, Camera, video, Controlled source electromagnetic array, Echosounder, Fluorometer, Gravimeter, Hydrophone, Light sensor, Lights, Methane sensor, Microbial incubator, Microbial sensor, Oxygen sensor, Plankton pump, Plankton sampling, Pressure sensor, Radiometer, Sediment trap, Seismometer, Sonar, multibeam, Sonar, sector scanning rotary, Temperature sensor, Turbidity Sensor, Water sampler, Junction Box, Node, Profiler, Vehicle, Gas Sensor, Accelerometer, Transmissometer, Gas tension device GTD, ZAP Zooplankton Acoustic Profiler, Instrument Adapter, Branching Unit, Sonar, profiling rotary, Compass



Interaction with underwater instruments

[Data Search](#) [Code Runner](#) [Plotting Utility](#) [Sea Tube](#) [Cameras](#) [Projects](#) [More](#) [Tools](#)

Logged in as **Benoit Pirenne** | [Profile](#) | [Logout](#)

NEPTUNE Canada **HD Panasonic Camera System** Beta
Oceans 2.0



Map Users Operator Communication



Satellite

Imagery ©2010 Terms of Use

Camera Preset Automated Observations

New Camera Preset ☐ Public *

Description

Run Save Delete

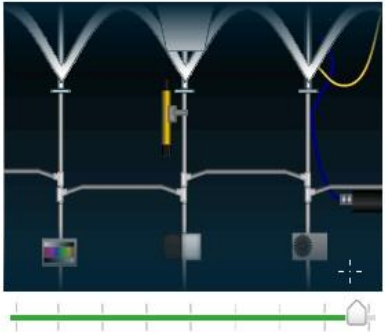
* Cannot be undone.

Camera Control

Left Lt Right Lt

72% 100%

Powerlight Off
Laser On



Pan

136.88°

Tilt

35.25°

Zoom Focus

2.556 2.152 m

☐ X2 Zoom

Menu

Timing

- NTP, PTP available at the instrument level (Ethernet switches transparent to PTP traffic)
- PTP Slave clock has to be implemented at the instrument level
 - In software (e.g., instrument's Linux kernel)
 - In hardware (PTP circuitry in instrument housing)
 - In an external can with PPS wire to the instrument

Search and Visualization, Products Access



[Data Search](#) [Code Runner](#) [Plotting Utility](#) [Sea Tube](#) [Cameras](#) [Projects](#) [More](#) [Tools](#)

NEPTUNE Canada **Data Search** Beta
Oceans 2.0

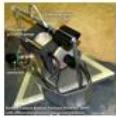
Logged in as **Benoit Pirene** | [Profile](#) | [Logout](#)

Instruments by: Instrument Type

- ADCP (acoustic doppler current profiler)
- BPR (bottom pressure recorder)
 - NRCan Bottom Pressure Recorder 59
 - NRCan Bottom Pressure Recorder 78
 - NRCan Bottom Pressure Recorder 83 (TP)
 - NRCan Bottom Pressure Recorder 83 Commissioning as of 20100912
 - NRCan Bottom Pressure Recorder 85
 - NRCan Bottom Pressure Recorder 87
 - NRCan Bottom Pressure Recorder 88
- Camera Pan And Tilt
- Camera, video
 - BW LOWLIGHT VIDEO CAMERA on PT DeviceID 12126
 - BW LOWLIGHT VIDEO CAMERA on PT DeviceID 12127
 - BW LOWLIGHT VIDEO CAMERA on PT DeviceID 12129
 - Pan/tilt/zoom web cam on crawler
- Compass

Search Templates

- My Search Templates
- Published Search Templates



NRCan Bottom Pressure Recorder 78 - 12501
Category: BPR (bottom pressure recorder)
[+ Documentation](#)
[+ More Info](#)

From 27-Sep-2010 23:35:02 Last 24 Hours

To 28-Sep-2010 23:35:02 [Reset Time Fields](#)

☐ Subsample Type: Average Period: Hour

Data Availability



	Time Series	Scalar Data	Time Series Scalar Plot	Log File
12501 - NRCan Bottom Pressure Recorder 78 (All Sensors)	☐	☐	☐	☐
4175 - Housing Temperature	☐	☐	☐	
1570 - P-sensor Temperature	☐	☐	☐	
4176 - Seafloor Pressure	☐	☐	☐	

Generate Results



Keep data and Meta-Data for 25 years

Device Id: 9 Device Name: **ASL Zooplankton Acoustic Profiler 1007**

General Sensor Ip Electrical Rating Data Rating Nameplate Port Physical Characteristics Device Action Event

Device Event Filter: ☒ Action ☒ IP ☒ Site ☒ Device Attribute ☒ Sensor Attribute

Page (1 of 3) << first < prev 1 2 3 next > last >> Page

Date	Type	Id	Description	Last Modified Date	Last Modified By
2006-08-04	Action	193	Recovering / Servicing / Redeployment - Maintenance	2008-06-17	Paul Macoun
2008-11-07	Action	194	Recovering / Servicing / Redeployment - Maintenance	2008-06-17	Paul Macoun
2007-02-02	Action	195	Recovering / Servicing / Redeployment - Maintenance	2008-06-17	Paul Macoun
2007-09-11	Action	196	Recovering / Servicing / Redeployment - Maintenance	2008-06-17	Paul Macoun
2008-02-26	Action	197	Recovering / Servicing / Redeployment - Maintenance	2008-06-17	Paul Macoun
2008-09-27	Action	415	Recovering / Servicing / Redeployment - Maintenance	2008-09-30	Paul Macoun
2009-03-16	Action	517	Recovering / Servicing / Redeployment - Maintenance	2009-03-16	Paul Macoun
2006-02-22	Action	15	Recovering / Servicing / Redeployment - Maintenance	2008-06-17	Paul Macoun
2009-09-30	Action	690	Removal - Maintenance	2009-10-05	Paul Macoun
2010-02-20	Ip	1419	10.40.40.129 - 10002	2010-02-20	Jaklyn Vervynck
2009-09-29	Ip	1177	10.40.36.131 - 10001	2009-09-29	Eric Guillemot
2009-01-26	Site	30044	VIP-01 (id = 16)	2009-01-26	Darryl Bidulock
2009-01-26	Site	30045	On Ship or Shore (id = 100005)	2009-01-26	Darryl Bidulock
2007-04-12	Site	5	VIP-02 (id = 3)	2007-04-12	Karen Tang
2009-01-26	Site	30046	On Ship or Shore (id = 100005)	2009-01-26	Darryl Bidulock

Keep data and Meta-Data for 25 years



**University
of Victoria**

MEDIA RELEASE

Oct. 27, 2009

OCEAN OBSERVATORY DATA HEADS FOR SASKATCHEWAN

The Pacific Ocean is about to flow into the Canadian Prairies.



NEPTUNE Canada

NEPTUNE Canada Science & Data Workshop, 12-14 April 2010



R1143 - 2008-06-27 03:56:35.0 - Upper continental slope near Barkley C. [v](#)

[Search All Dive Videos](#) [He](#)

2008-06-27 04:29:00
N4821.2687 W12607.7801 0457 0852

[Map](#) [Profile](#) [Detail](#)

PI:
Area:
Start Date:
End Date:
Dive Plan:
[v](#) [v](#)



Annotation ✕

Dive: R1143 Upper continental slope near Barkley C.

From: [Point In Time](#) [v](#)

To: [Reset Time Fields](#)

☐ Share (Cannot be undone)

☐ Flag

12:53

Time	Comment
2008-06-27 04:23:07	second brittle star in the port biobox
2008-06-27 04:23:41	
2008-06-27 04:23:51	
2008-06-27 04:24:04	
2008-06-27 04:26:12	going after the sea cucumber
2008-06-27 04:27:54	tunicates
2008-06-27 04:28:23	another shot
2008-06-27 04:28:55	

48.35441	-126.12955	456.3
48.35442	-126.12956	456.4
48.35442	-126.12956	456.4
48.35443	-126.12956	456.2
48.35448	-126.12967	456.5
48.35448	-126.12967	456.5
48.35448	-126.12967	456.5

Early Results: Seismic and Tsunamis

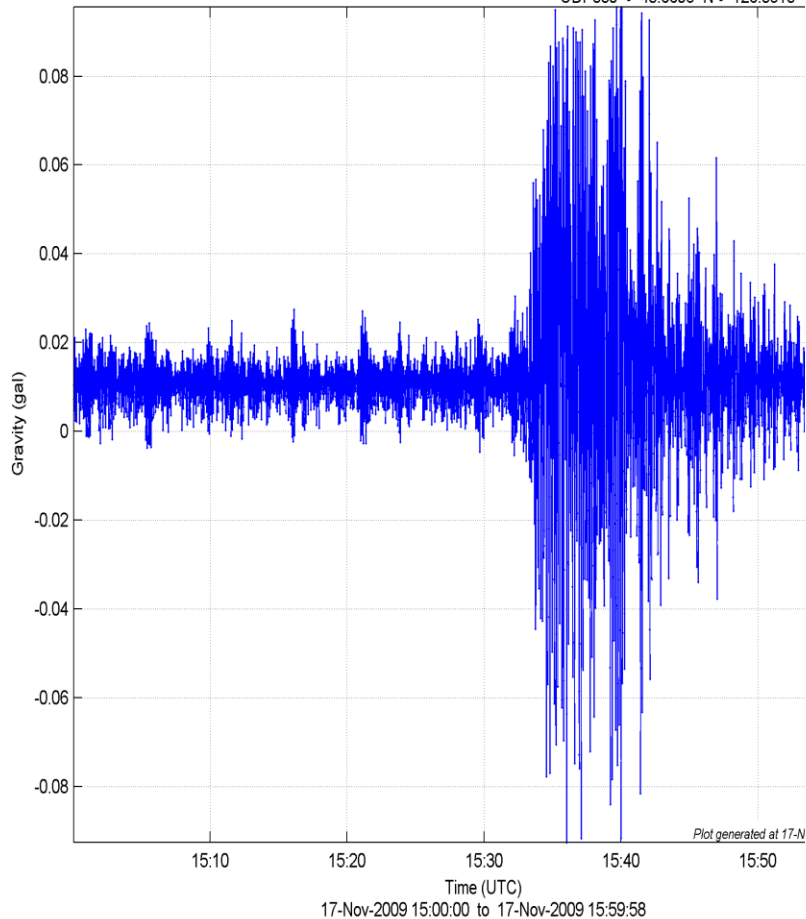


NEPTUNE Canada Oceans 2.0

Infrastructure Data Access User Tools Instruments Administration



Seafloor Compliance (SFC) (DeviceID: 22001) • Gravity (Ser
ODP889 • 48.6695° N • 126.8518° W)



Plotting Utility

Category: BPR (bottom pressure recorder)

Date Range: Custom

Device: BPR Folger 83

Start Date: 30-Sep-2009 04:00:00

Sensor: Total Pressure 1

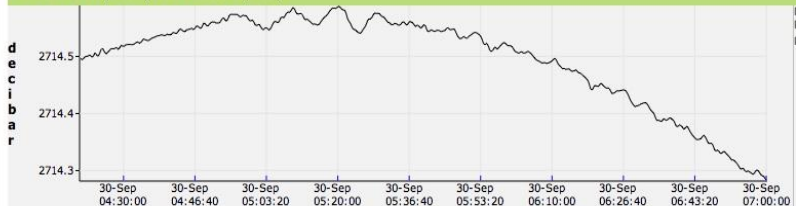
End Date: 30-Sep-2009 07:00:00

Add Plot

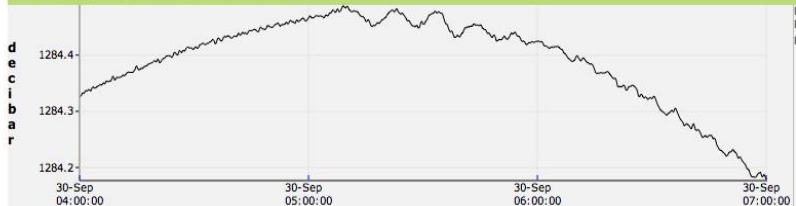
Update Plot(s)

Previous Time Period Next Time Period

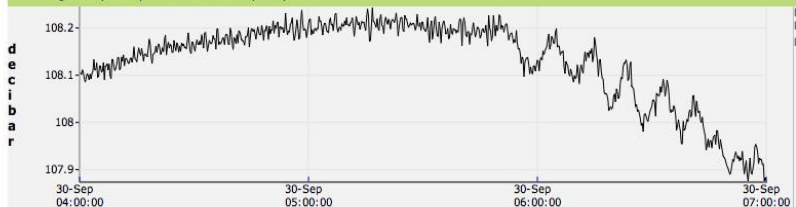
BPR 1027 S 87 (21502) Total Pressure (4185)



BPR ODP889 88 (22503) Total Pressure (4191)



BPR Folger 83 (20501) Total Pressure 1 (4179)



Challenges re. exploitation of the data:

- Observatory is an expensive, unique, shared resource: requires management
- Ocean data volumes to be *multiplied by 10^6 / year*
- *Constant* number of scientists available to deal with them
- Need to change the old “expeditionary science” paradigm
- Need new tools to deal with the issue of analysis, visualization
 - --> Need to create an environment for collaboration
 - --> Provide tools to support effective exploitation of data

Approach

- Take advantage of **Web 2.0 paradigms** to address issues
 - Every tool is on-line, web-enabled
 - Don't download data – upload code instead
 - Every Web tool has aspects of **contribution & collaboration**
- Other Challenges:
 - Sociological: get people to change the way they work
 - IT: build an eScience/Cyber-Infrastructure environment adapted to Ocean scientist needs (many different disciplines!)



Test Tsunamis

[Home](#)[Bottom Pressure](#)

A tsunami is a huge ocean wave that can travel at speeds up to 600 mi/hr (965 km/hr), hundreds of miles over open sea before it hits land. Sometimes incorrectly called a tidal wave, a tsunami is usually caused by an earthquake, volcanic eruption, or coastal landslide.

Tsunami is Japanese for "harbor wave." It is, in fact, a series of waves which travel outward on the ocean surface in all directions in a kind of ripple effect. Since the waves can start out hundreds of miles long and only a few feet high, they would not necessarily be noticeable to a passing ship or a plane flying overhead.

As the waves get closer to shore, they decrease in speed and increase in height. They approach the coastline as a series of high and low water levels, approximately 10-45 minutes apart, with their speed decreasing to about 30-40 mi/hr (50-60 km/hr). The depth of the water and the layout of the coastal area can affect the tsunami's configuration when it hits the shore. It can grow to 30-50 meters high and smash into the shore as a wall of water or sweep over the land as a fast-moving flood. Although tsunamis can happen in any large body of water, most occur in the Pacific Ocean.

Community Members

[Ronald A Schouten](#)[Eric D Guillenot](#)[Benoit Pirenne](#)[Reyna Jenkyns](#)

Invite others to this Project

[Invite Users](#)

Join or Leave this Project

[Leave](#)[Configure Portal for user spaces](#)[Add Comment](#)

Add a page

[Add new page](#)

Discussion

[Forums](#)[Topics / Replies](#)[Last Reply](#)

There are no forums to display

[View Options](#)[Edit Tools](#)**Child Pages (1)** [Show Child Pages](#) | [View in Hierarchy](#) | [Add Child Page](#)Added by [Ronald A Schouten](#), last edited by [Ronald A Schouten](#) on 08-Sep-10 ([view change](#))[ADD LABELS](#)

Currently opened
Matlab code
(Editor)

Shared code, Templates

Matlab result

Display window

The screenshot shows a file explorer window with the following structure:

- BenthicStudy
 - MeanCurrents
 - TSAnalysis
 - libs
 - results
 - BC_POD4_CTD25_20100628T0000.mat
 - SBECTD16p6001_20100615T000052.mat
 - SBECTD16p6001_20100615T000052.png
 - tsplot.png
 - src
 - simple.m
 - templateSeabird16plusCTDTimeSeries.m
 - templateWetlabsECOFLNTTimeSeries.m
 - tsplot.m
 - CTDTimeSeries
 - HydrophoneProject
 - BPRPressures
 - testBioSonics
 - testIRDIADCP

```

18 enddate='15-June-2010 11:59:00 PM';
19
20 % Sensor IDs: If you do not know your sensor id
21 % refer to the Device Listing at http://dmas.uvic.ca/, and select the
22 % of sensors and their ids
23
24 % e.g., for device id=20220
25     deviceID=20220;
26     neptune(1).sensorID=4261; % Conductivity
27     neptune(2).sensorID=4260; % Temperature
28     neptune(3).sensorID=4262; % Pressure
29     neptune(4).sensorID=6965; % Salinity
30
31 % Retrieve entire time series and basic metadata for each sensor
32 % NOTES:
33 % a) Data will only be returned for NEPTUNE
34 % completed commissioning.
35 % b) If your time series is too long, you
36 [neptune,meta,nd]=getData(neptune,startdate,
37                             enddate,deviceID);
38
39 % For subsampled data, use additional arguments
40 % subsampletype options: 1=Averaged data
41 % subsampleperiod options (seconds): 3600
42 % weekly
43 [neptune,meta]=getData(neptune,startdate,
44                             enddate,deviceID,
45                             1,3600);
46
47 % Create a plot of the results if data returned
48 if ~nd
49     figure(1);
50     clf;
51
52 % Plot the data
53 % Note: The data is plotted in the order of the sensor IDs
54 % specified in the neptune structure.
55 % The x-axis is time (UTC) and the y-axis is the sensor value.
56 % The legend is located in the top right corner of the plot.
57 % The plot is titled 'NEPTUNE Data' and the axes are labeled 'Time'
58 % and 'Sensor Value'.
59 % The plot is a line plot with markers at each data point.
60 % The plot is a line plot with markers at each data point.
61 % The plot is a line plot with markers at each data point.
62 % The plot is a line plot with markers at each data point.
63 % The plot is a line plot with markers at each data point.
64 % The plot is a line plot with markers at each data point.
65 % The plot is a line plot with markers at each data point.
66 % The plot is a line plot with markers at each data point.
67 % The plot is a line plot with markers at each data point.
68 % The plot is a line plot with markers at each data point.
69 % The plot is a line plot with markers at each data point.
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Published Packages
Murray 0.1 [2010-08-20]
Test Publish 0.01 [2010-08-18]
Testing Publish Mito 0.1 [2010-08-20]
canariePublish 1.01 [2010-09-08]
pack0908b 1.0.0.1 [2010-09-08]
pack20100908 0.0.0.1 [2010-09-08]
rTest 1.01 [2010-09-08]
sdfasdfsdfasdf 1.4 [2010-08-26]
test-1.0 [2010-08-20]
test 0.0010 [2010-08-20]
test 1.0 [2010-08-20]
test 1.0000 001 [2010-08-20]
Running file canarieDemo/src/simple.m
```



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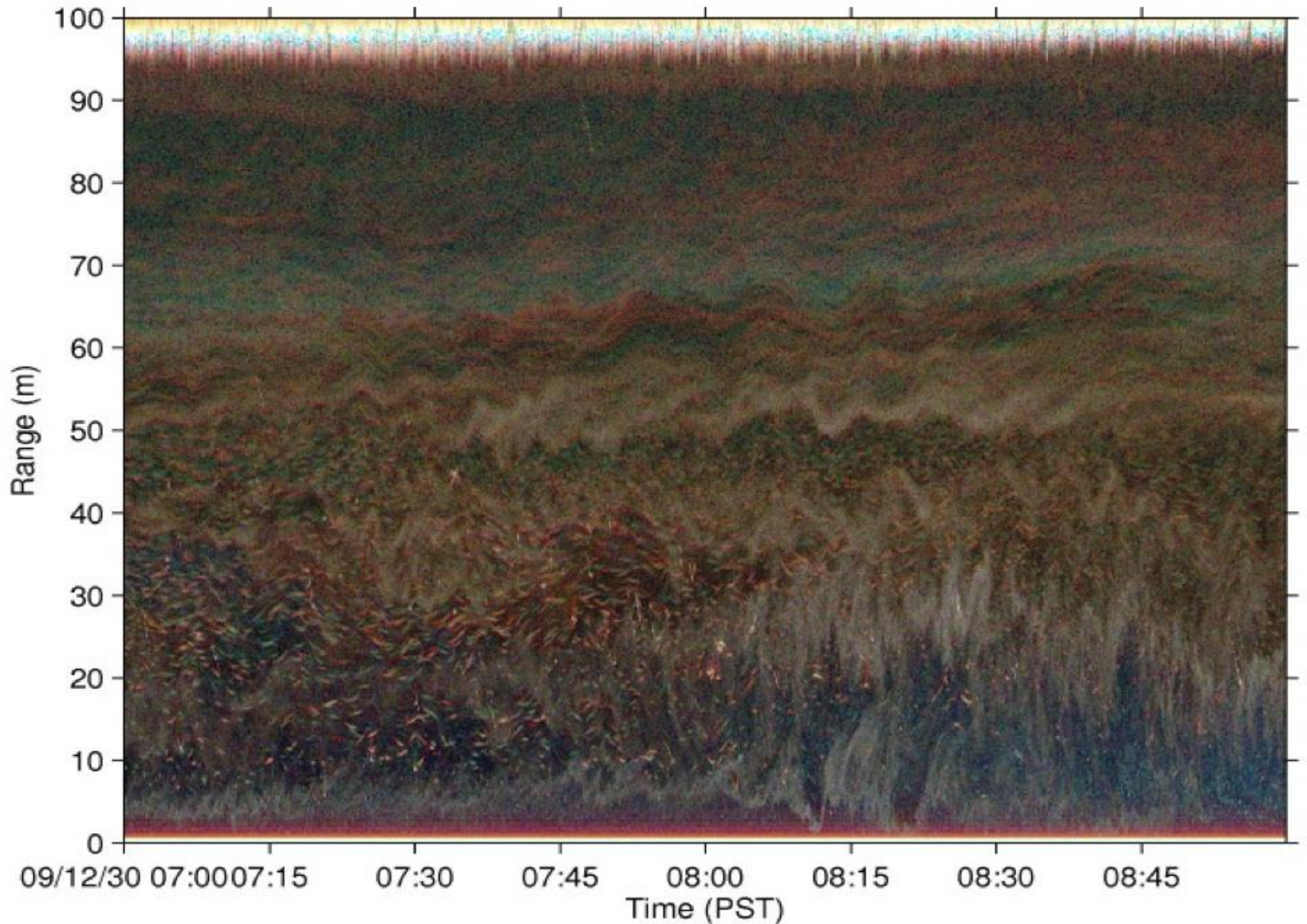
Transforming Ocean Science



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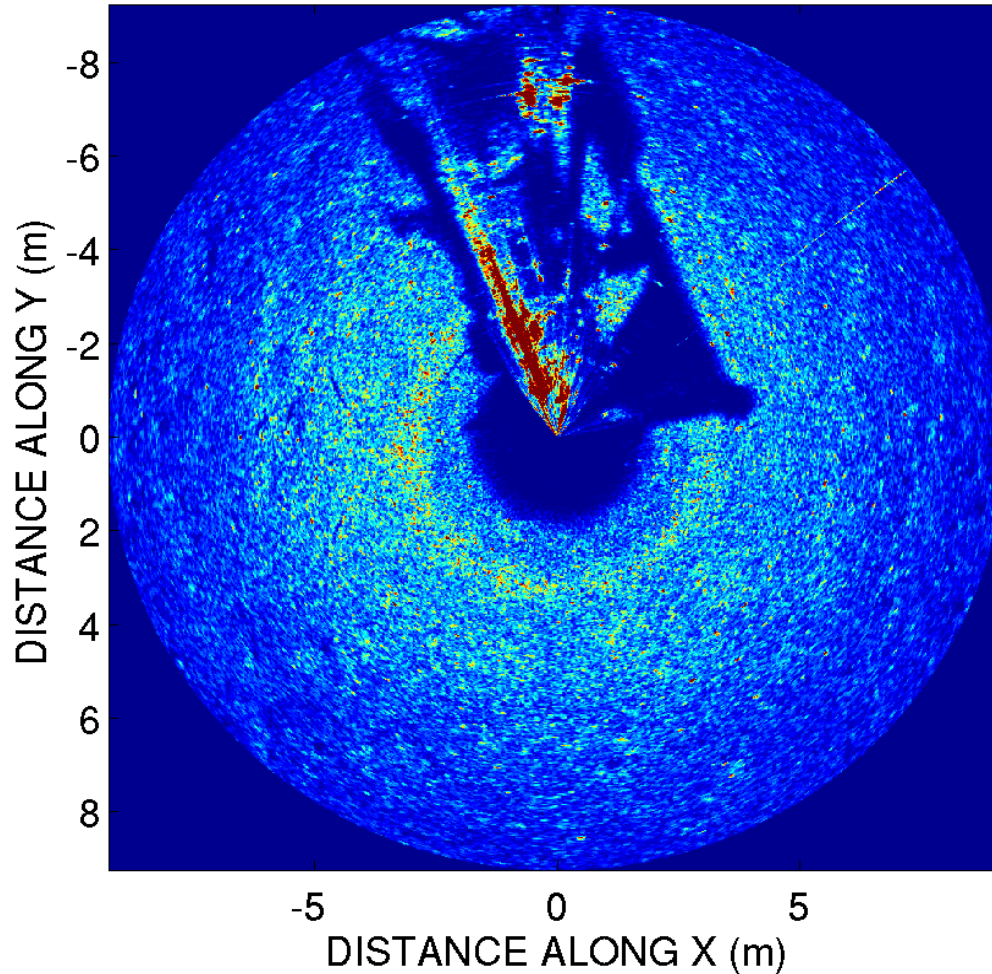
NEPTUNE Canada Science & Data Workshop, 12-14 April 2010

Early Results: Water Column Ecology



Early Results: Formation of “pits” in the Sediment

CANYON WALL, 675 kHz, 0.02m RESOLUTION



Early Results: Benthic Fauna

- The entirety of the study area's surface has been turned over during the 90 days of this survey (Kat Robert).



Science Results

- Many more to come!



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