# Twenty-First Century Oceanography: The Ocean Observatories Initiative

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**University of Washington**

**with input from Deb Kelley (UW), Bob Collier (OSU) and Mike Kelly (UW)**

- **Oceanography off the Pacific Northwest**
- **New tools and approaches**
- **NSF's Ocean Observatories Initiative (OOI)**
- **OOI plans off the Pacific Northwest**
- **Next steps**

Oregon State University OSU

UNIVERSITY OF WASHINGTON

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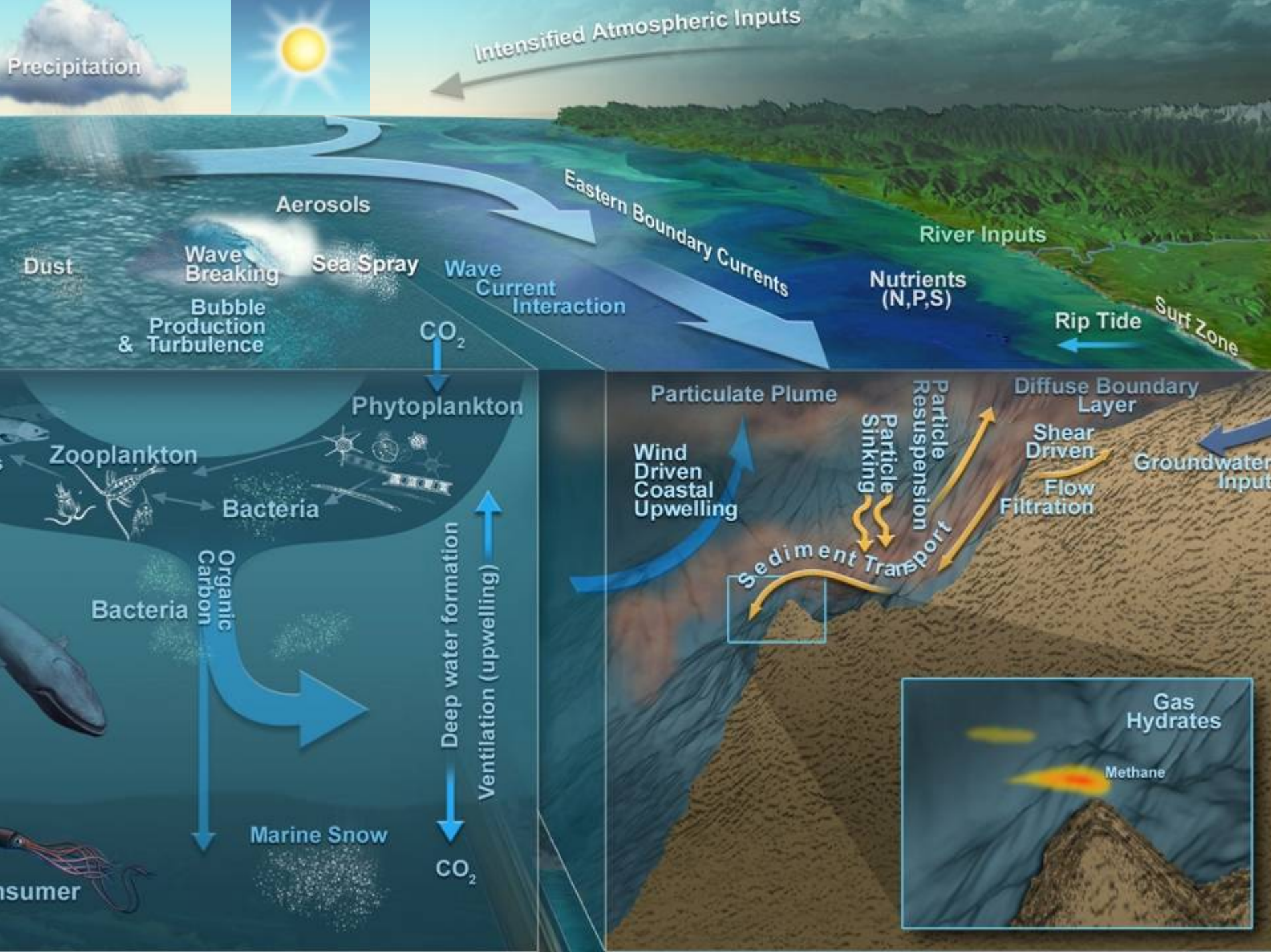
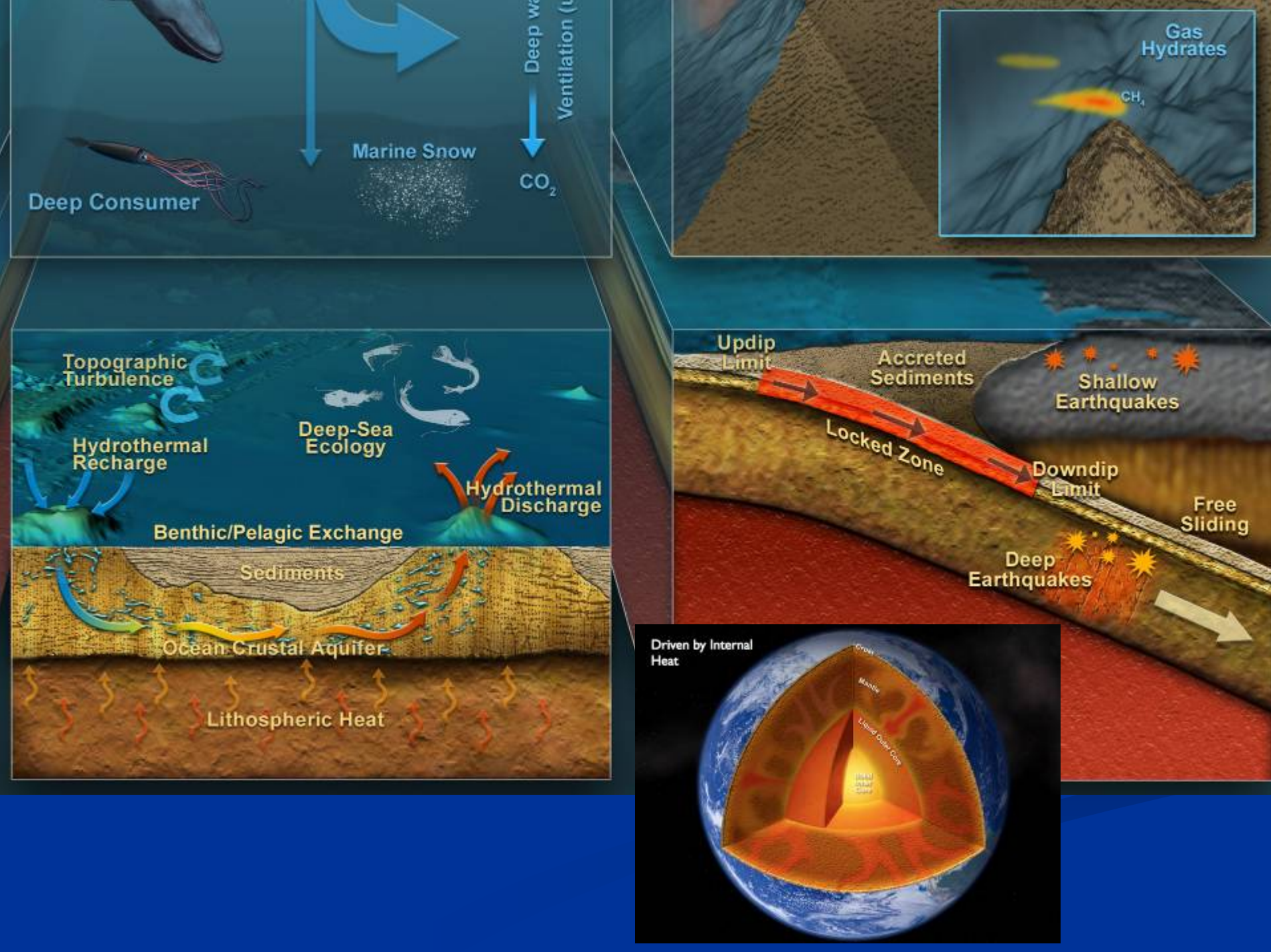
# The Planetary Ocean:

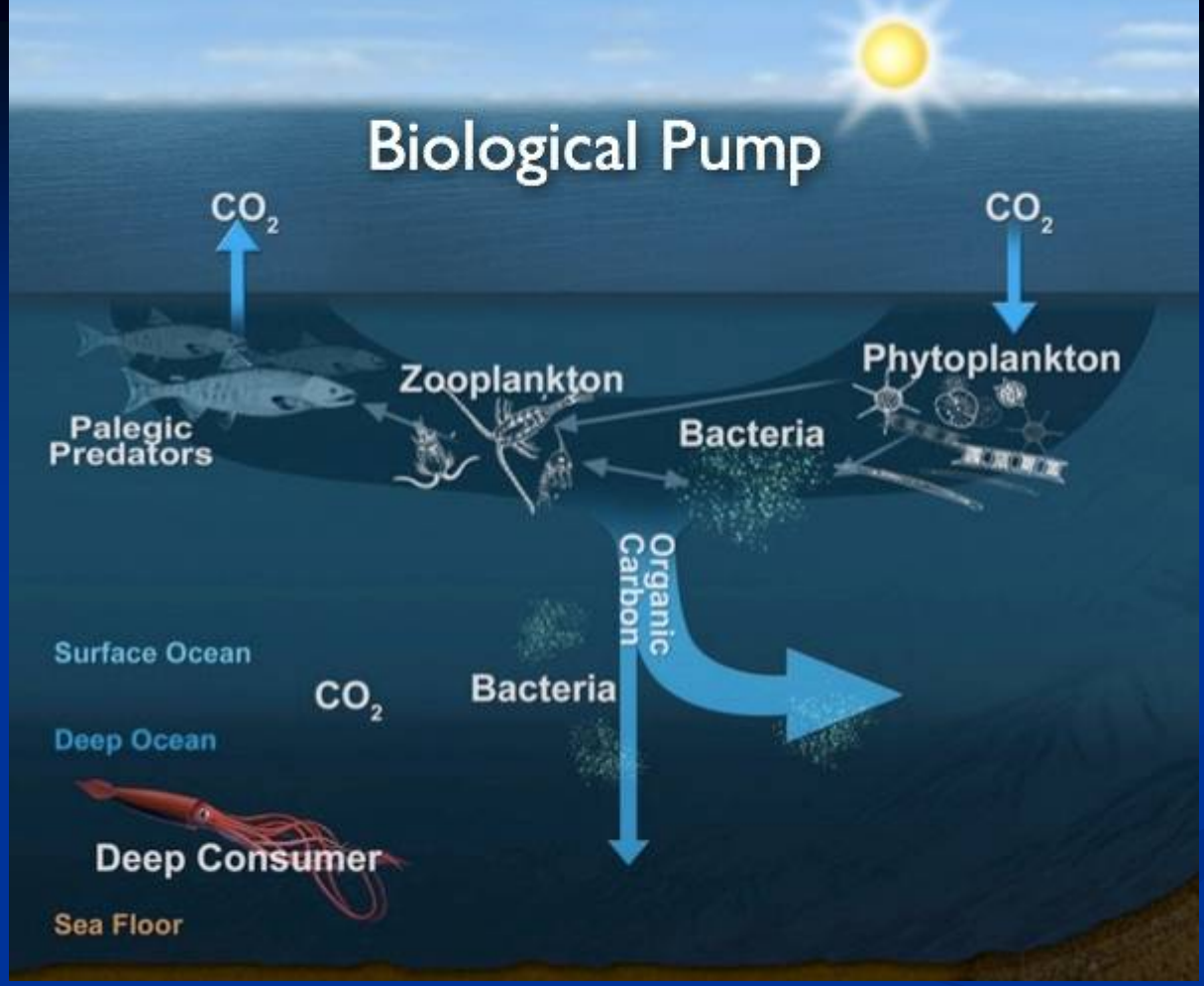
- Is the last physical frontier on earth.
- Covers 70% of planetary surface.
- Was the 'locus' for Origin of Life?...Biocomplexity
- Is a huge reservoir of heat and chemical mass.
- Functions as the 'flywheel' of planetary climate.
- Absorbs half the carbon from fossil fuel conversion.
- Is the ultimate repository of human waste.
- Generates hazards - often unpredictable.
- Is a vast repository of living and non-living resources.
- Touches most nations, all continents.


Precipitation
Intensified Atmospheric Inputs
Aerosols
Eastern Boundary Currents
River Inputs
Dust
Wave Breaking
Sea Spray
Wave Current Interaction
Nutrients (N,P,S)
Bubble Production & Turbulence
$CO_2$
Rip Tide
Surf Zone
Phytoplankton
Zooplankton
Bacteria
Organic Carbon
Deep water formation
Ventilation (upwelling)
Bacteria
Marine Snow
$CO_2$
nsumer
Particulate Plume
Particle Resuspension
Particle Sinking
Diffuse Boundary Layer
Shear Driven
Flow Filtration
Groundwater Input
Wind Driven Coastal Upwelling
Sediment Transport
Gas Hydrates
Methane


Deep Consumer
Marine Snow
$CO_2$
Gas Hydrates
$CH_4$
Topographic Turbulence
Deep-Sea Ecology
Hydrothermal Recharge
Hydrothermal Discharge
Benthic/Pelagic Exchange
Sediments
Ocean Crustal Aquifer
Lithospheric Heat
Updip Limit
Accreted Sediments
Shallow Earthquakes
Locked Zone
Downdip Limit
Free Sliding
Deep Earthquakes
Driven by Internal Heat
Crust
Mantle
Liquid Outer Core

# A Few Major Questions

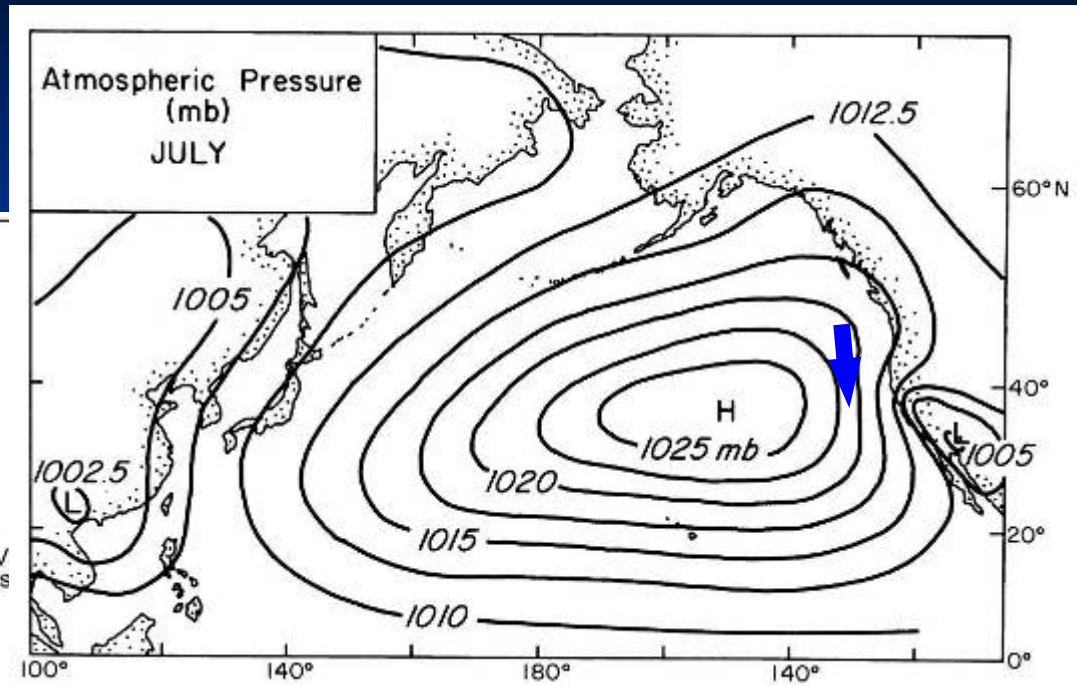
- What are the links between ocean dynamics and continental food production?
- Can climate change impact coastal ecosystems and alter the ocean carbon cycle?
- Is there a synoptic way of establishing the 'health of the oceans?
- Are there critical 'Tipping Points' in ocean-atmosphere behavior?
- How does the newly discovered sub-seafloor biosphere function?
- What events/processes control the formation and destruction of Natural Resources within the ocean basins?

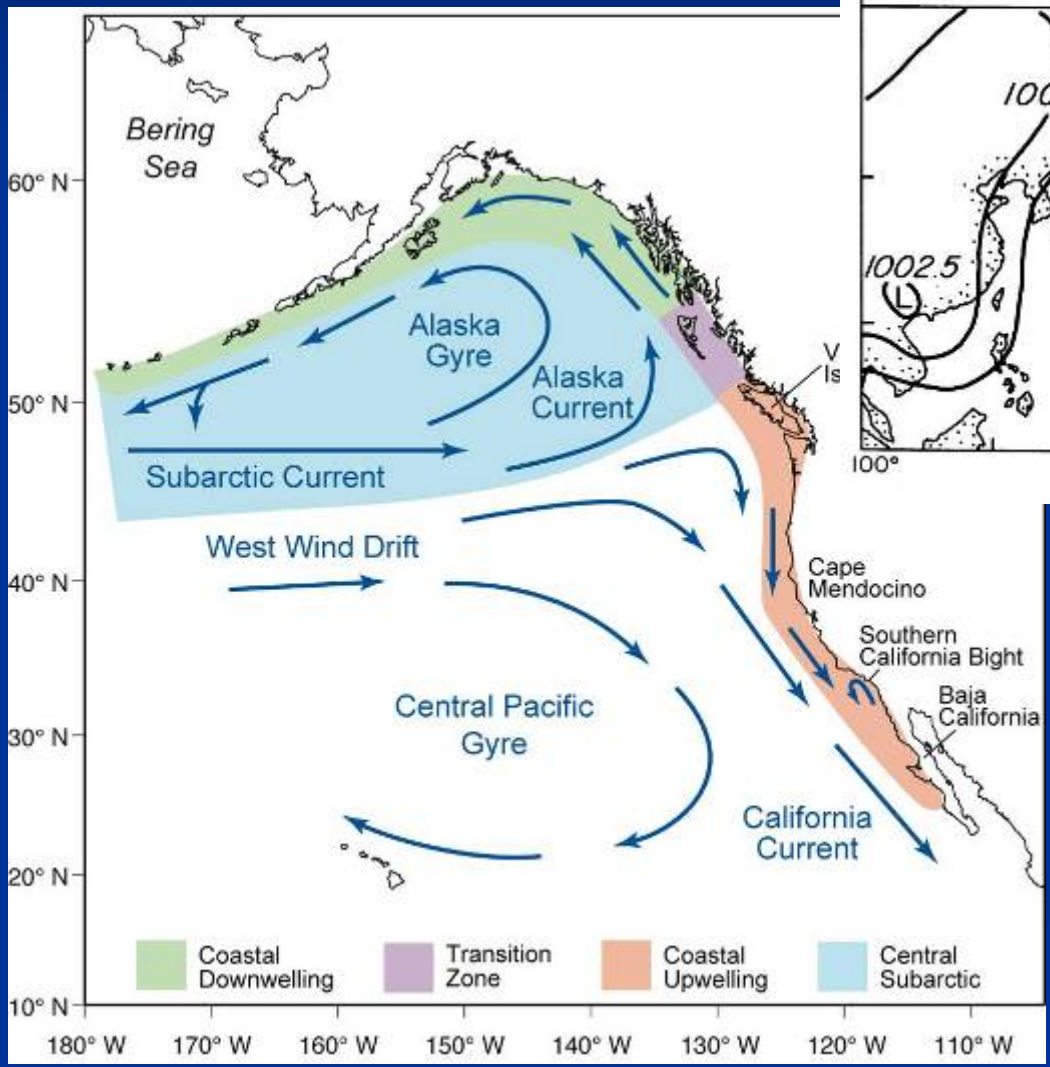



About half of all $CO_2$ emitted due to burning of fossil fuels has ended up in the oceans

Sabine et al., 2004, Science 305:367-371.

# Wind Forcing and Large-Scale Circulation

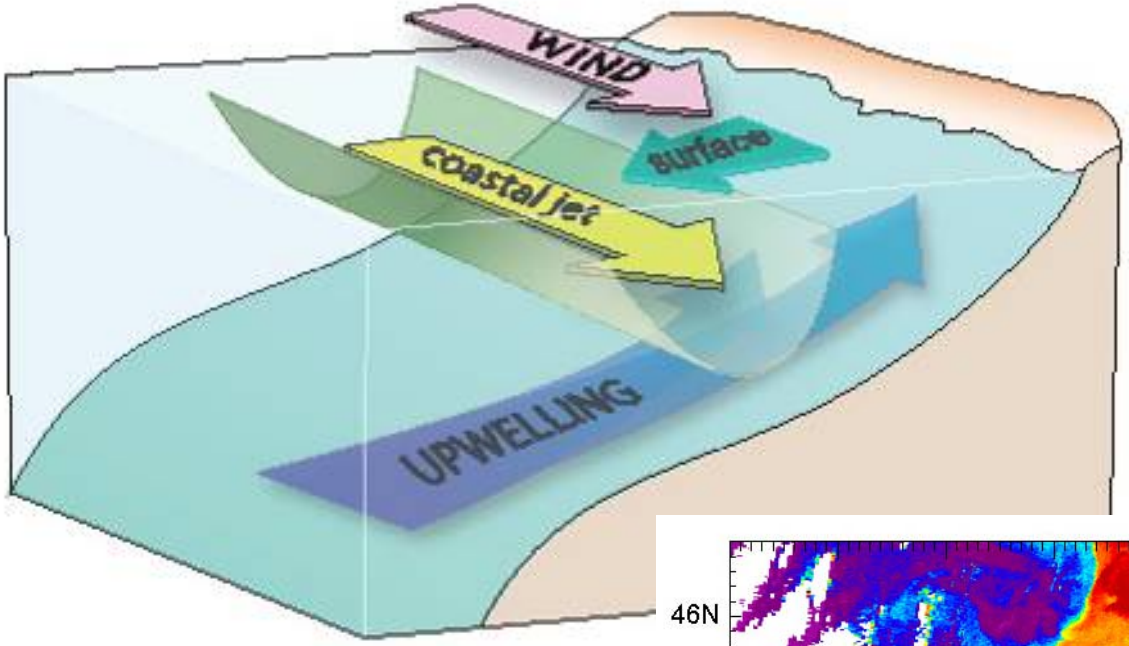


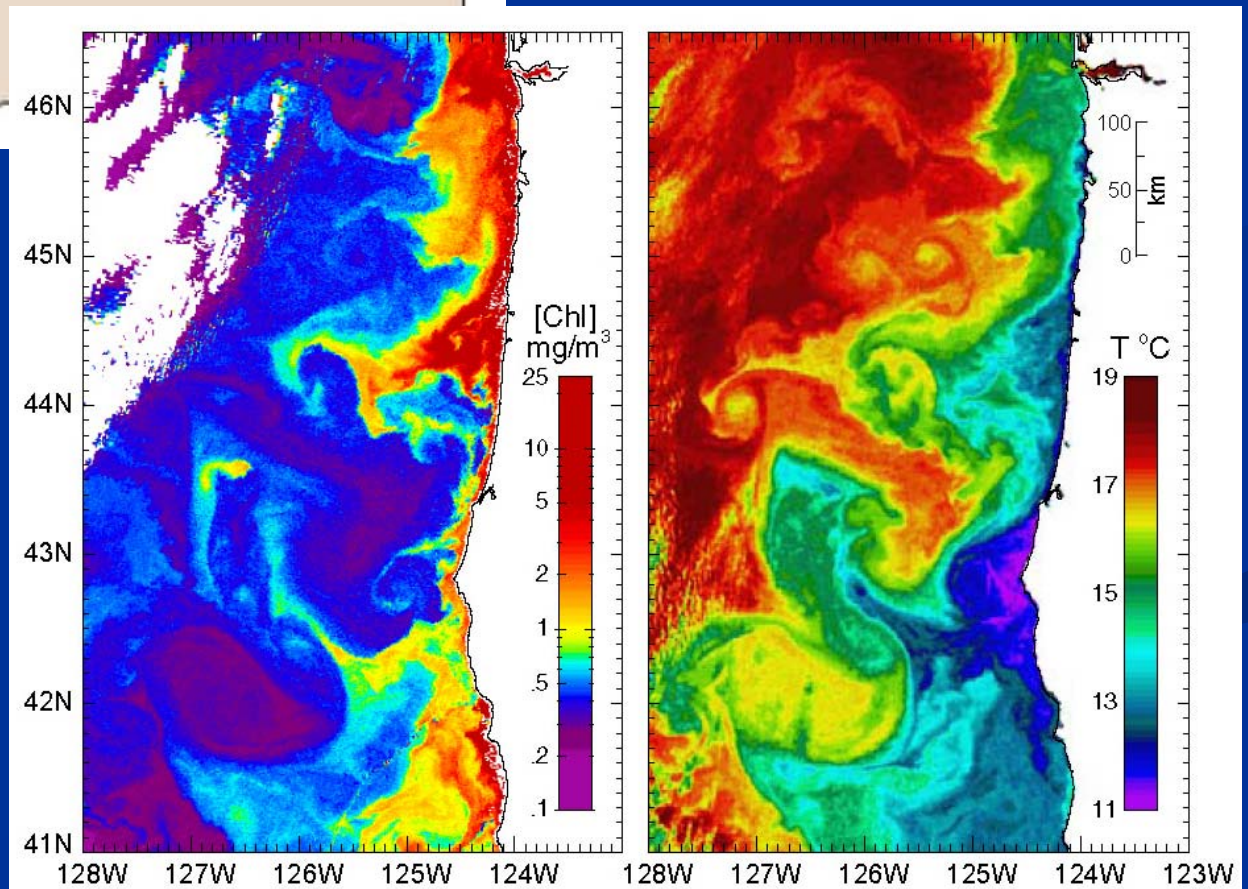

## North Pacific High
## &
## Continental Low

Huyer (1983)

# Upwelling




## satellite chlorophyll and temperature

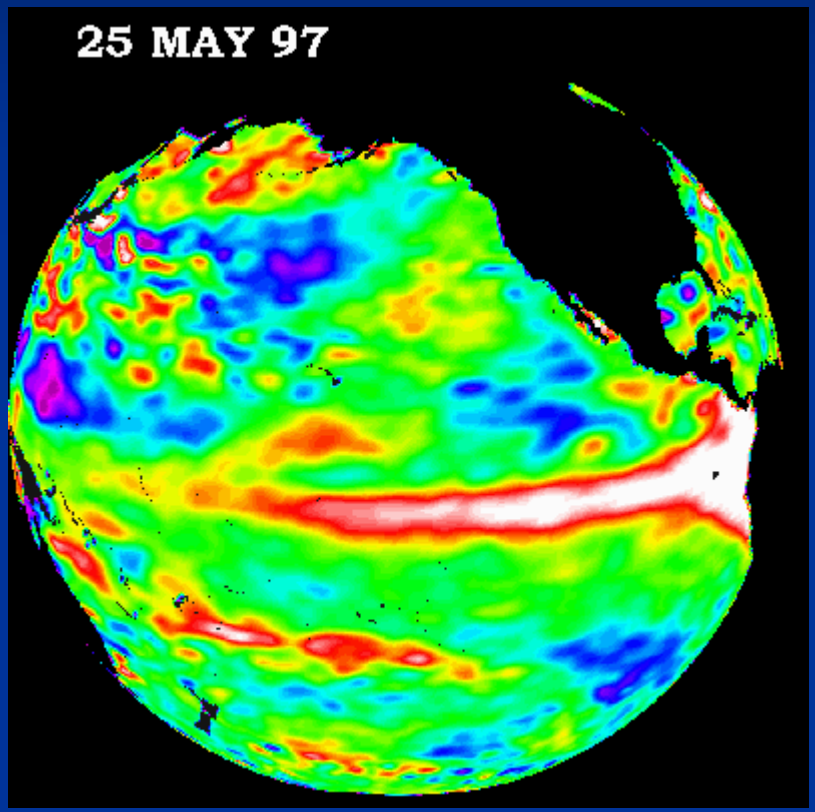


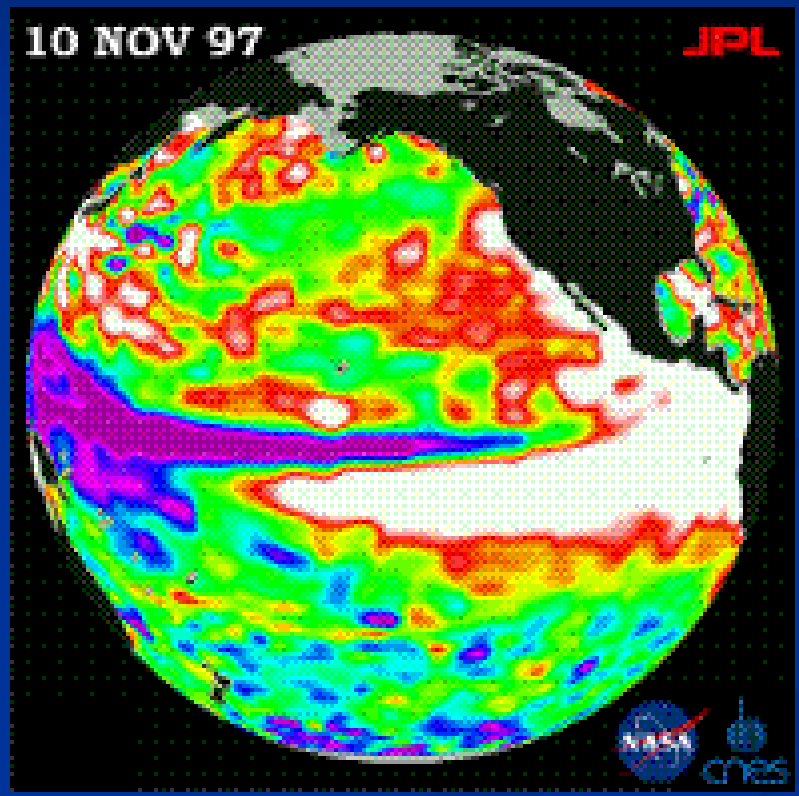

**Coastal oceans:**
**1% of ocean area**
**25% of wild caught seafood**

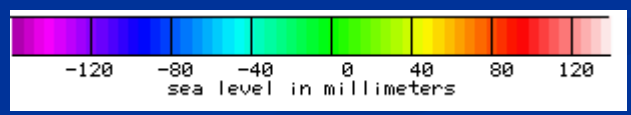
# Interannual Variability

## (mechanisms well understood)

El Niño Southern Oscillation (ENSO) cycle



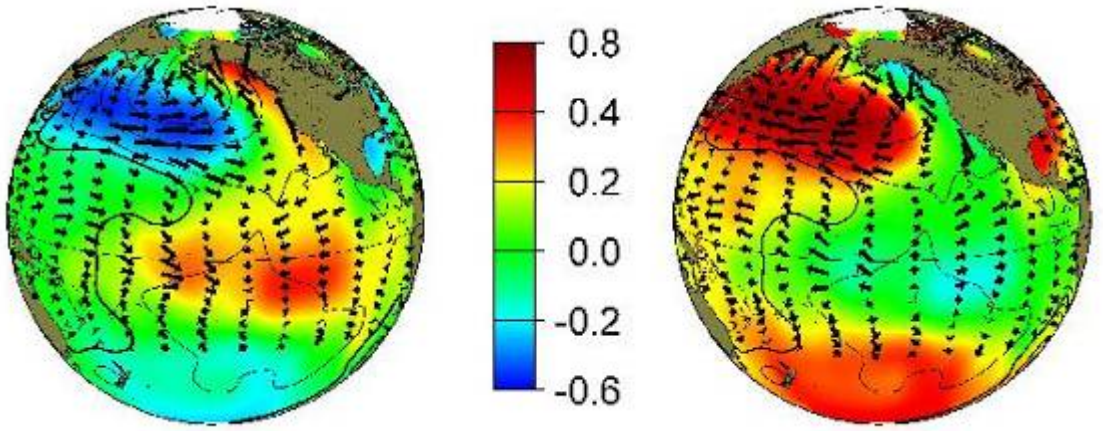

low sea level = cold

high sea level = warm

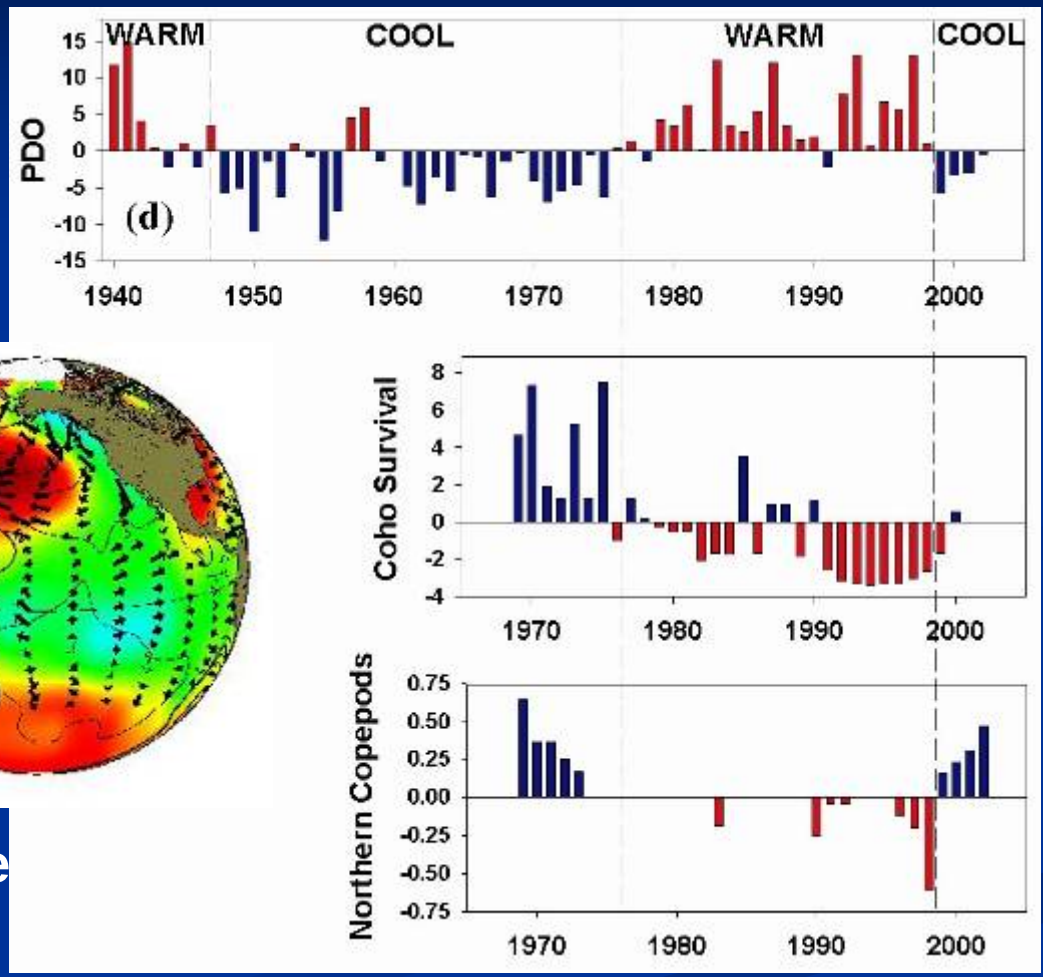
NASA

# Interdecadal climate variability
## (mechanisms poorly understood)

**Pacific Decadal Oscillation**




**warm phase** **cool phase**




http://tao.atmos.washington.edu/pdo/

Peterson and Schwing (2003)

# Hypoxia in 2002 and a Subarctic water invasion significant fish and Dungeness crab die-offs

**Normal Inner-Shelf Rockfish Community**



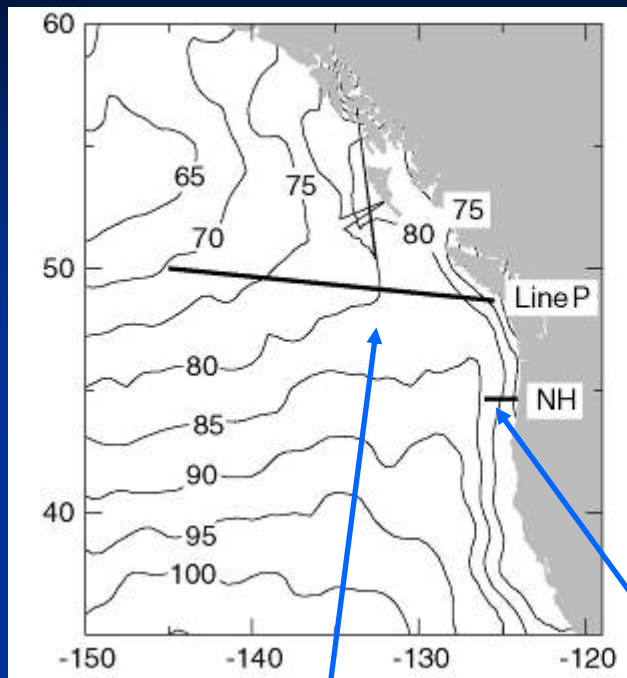
**July 2002**

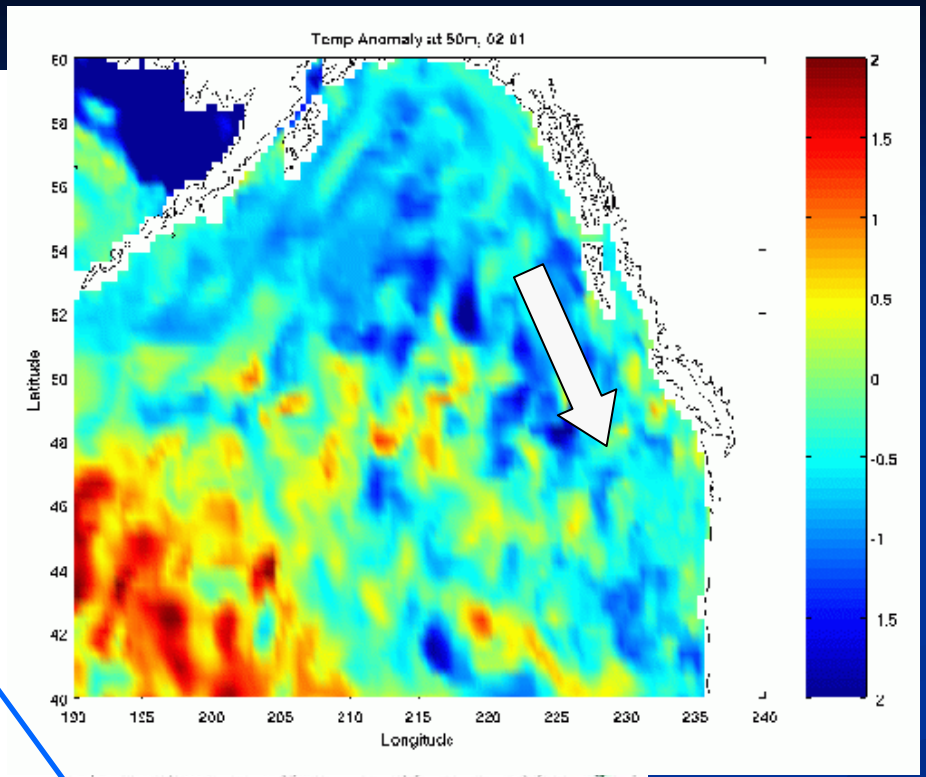
**2004**

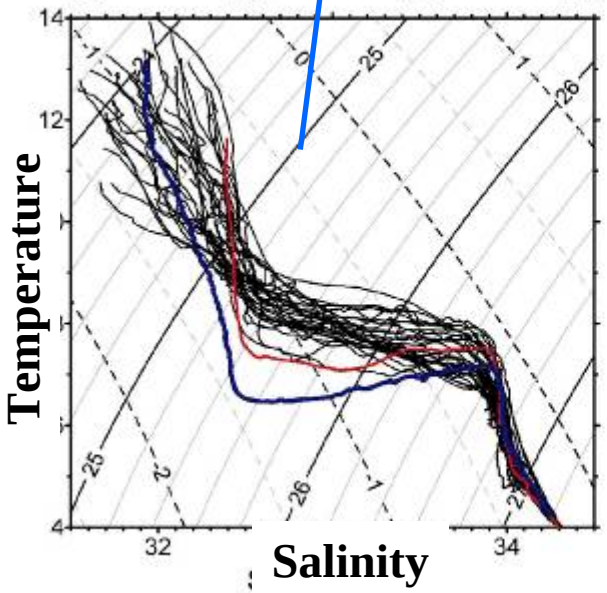


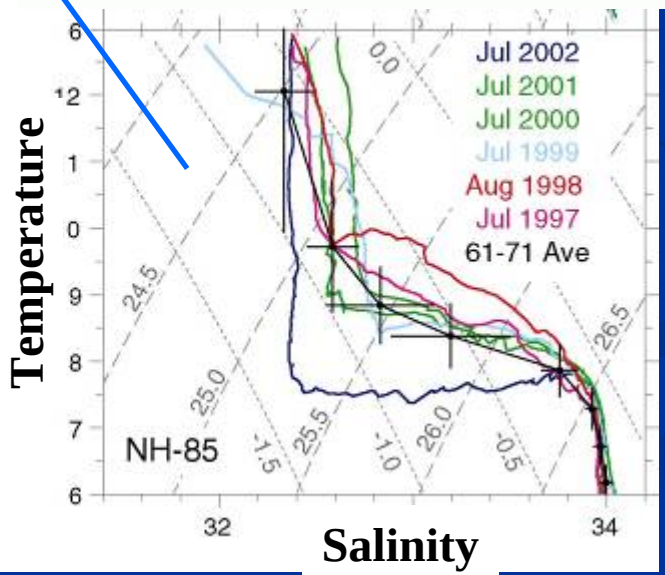

Grantham et al. (2004)

# 2002: Invasion of nutrient-rich subarctic water into the California Current



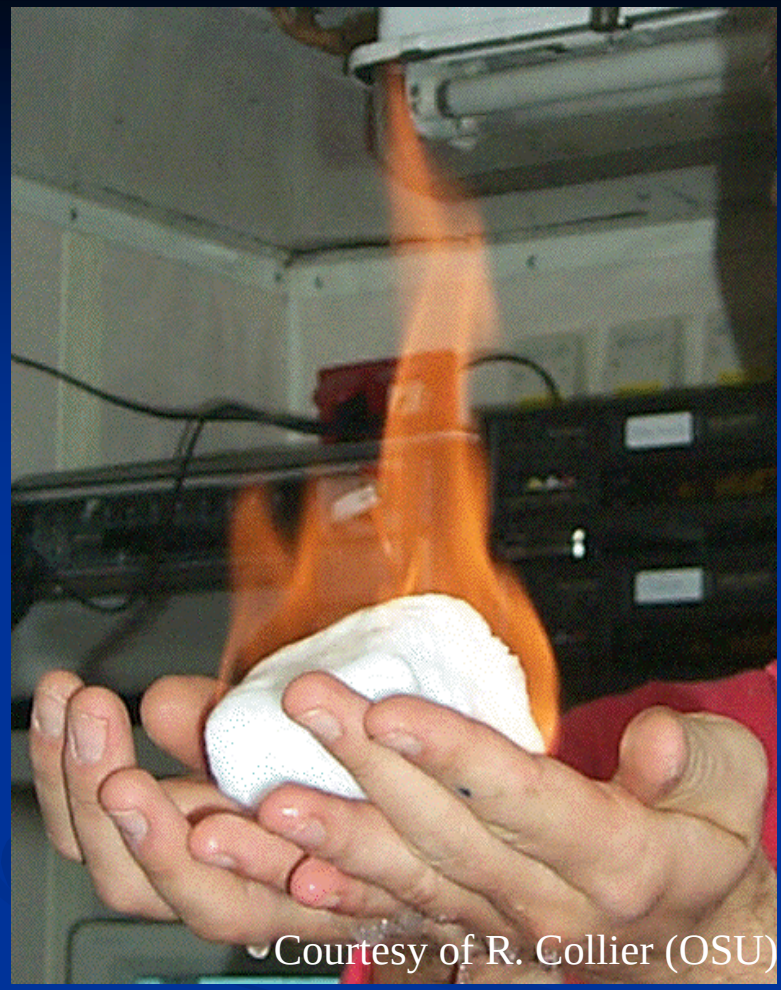



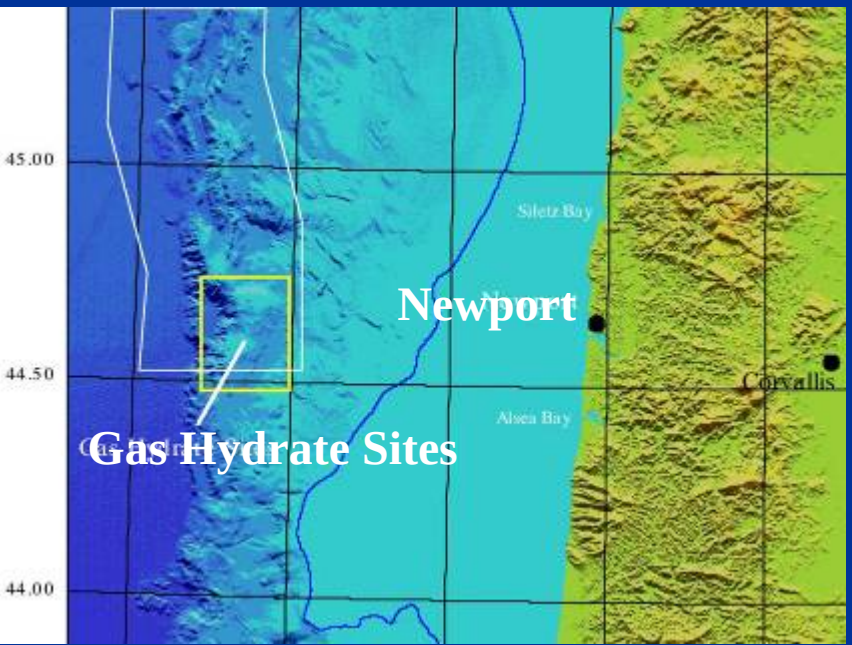




Freeland et al. (2003)

# Methane Hydrates

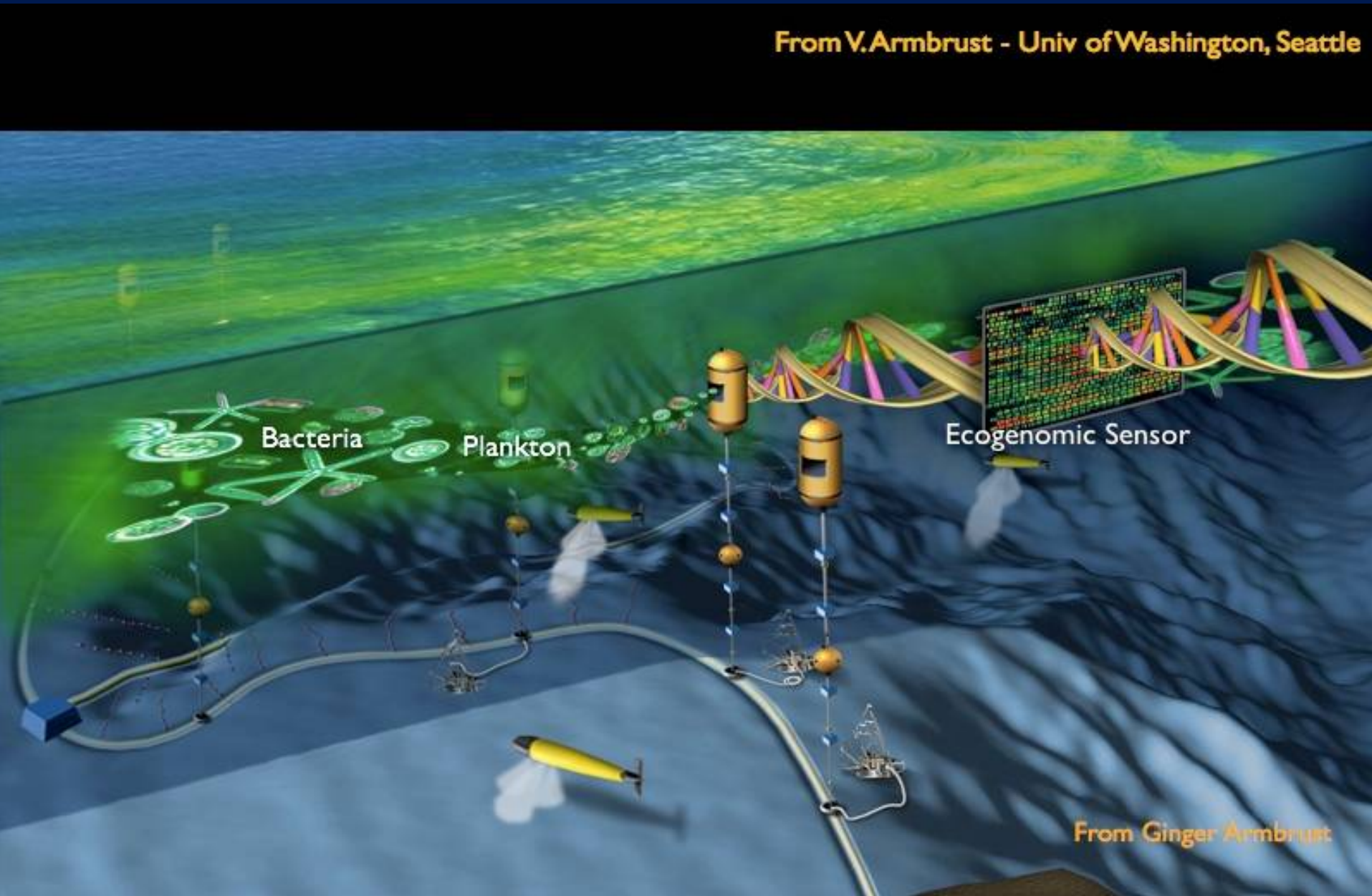


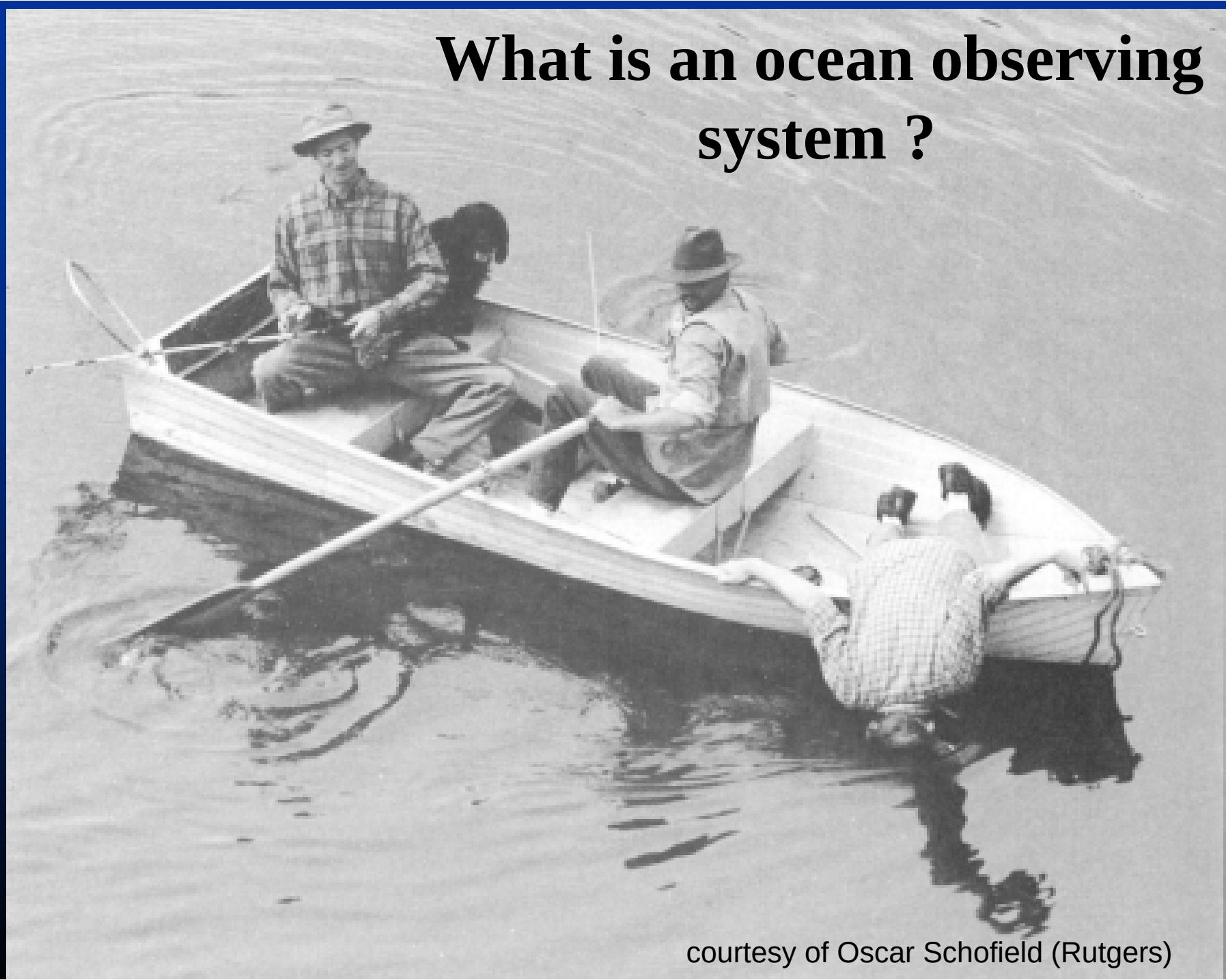

**Global distribution of organic carbon**

- **10,000 Gigatons of gas hydrates**
- **5,000 Gigatons of oil, gas and coal**
- **1,400 Gigatons in soil**
- **830 Gigatons in land biota**

# Detection of Harmful Algal Blooms



# What is an ocean observing system ?



courtesy of Oscar Schofield (Rutgers)

# NEXT GENERATION EARTH AND OCEAN SCIENCES

***The Vision:***

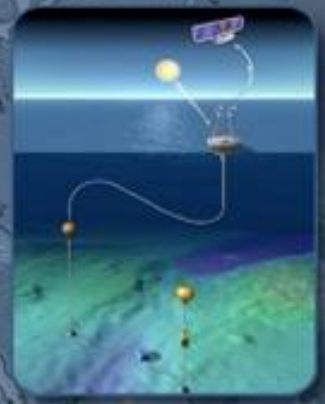
***To enable routine, ~real-time, remote interactions between land-based user communities and 1000's of in situ, robot-sensor arrays within the ocean basins.***

***The Goal:***

***Detect, respond to, quantify, model, understand and appreciate the time-scales and the impacts of change in Ocean processes.***

***"The Key is Interactivity"***

***"The Solution is Power and Bandwidth"***



"ORION"
Ocean Research Interactive Observatory Networks

**Ocean Observatory Initiative (OOI)**

"EXPLORING THE TIME-DOMAIN"

A PROGRAM INITIATED AND FUNDED BY
THE NATIONAL SCIENCE FOUNDATION

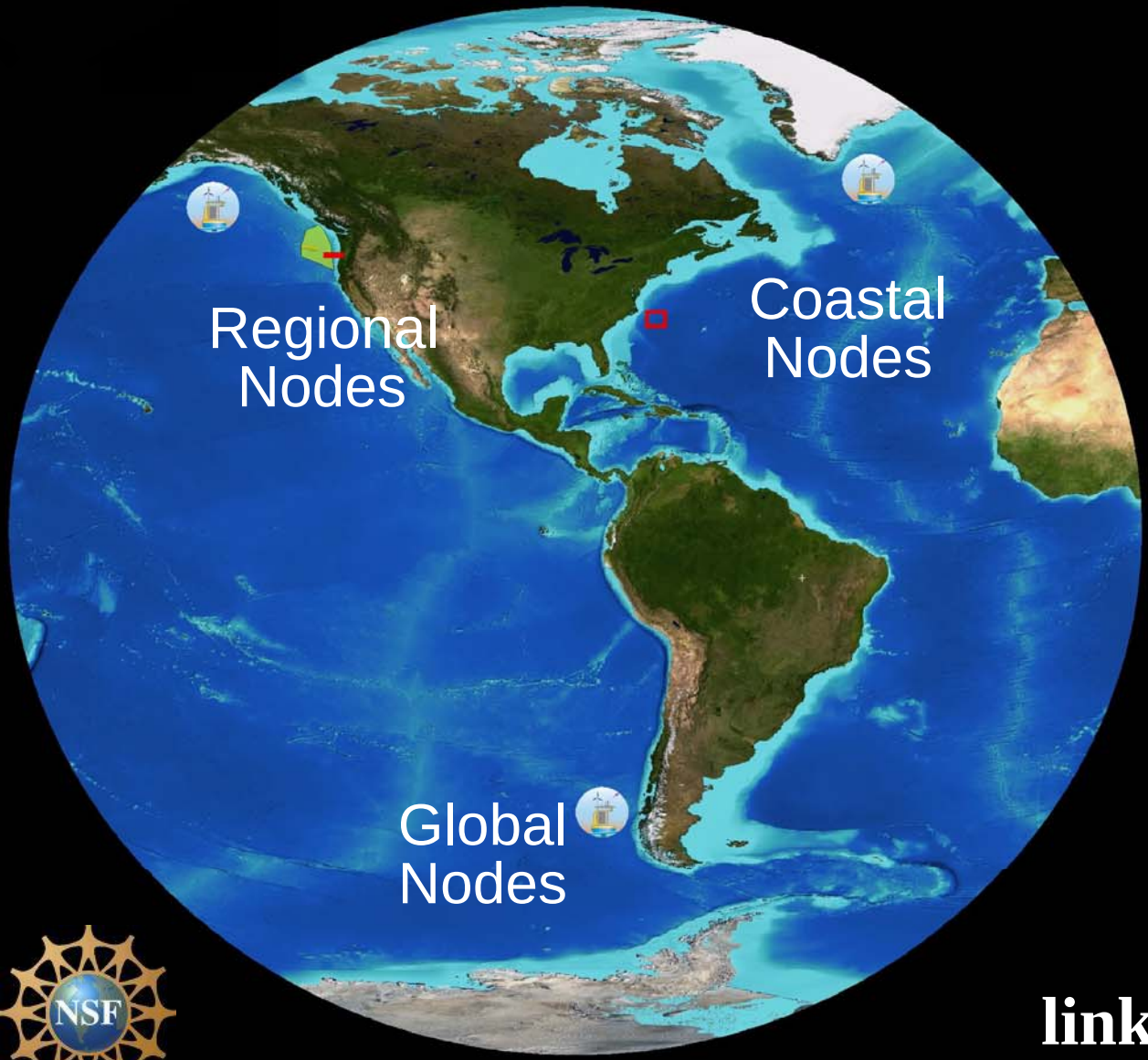
(Major Research Facilities Construction Fund)

**$331 M over 6 years**

**Fall 2007 Science Plan & Review**
**Dec 2007 Project Design Review**
**Winter 2008 NSB Review**
**Spring 2008 Funds start flowing**

NSF

# Ocean Observatories Initiative




## Regional Scale Node

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## Global Scale Node

## Coastal Scale Node

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

OSU

SCRIPPS INSTITUTION OF OCEANOGRAPHY

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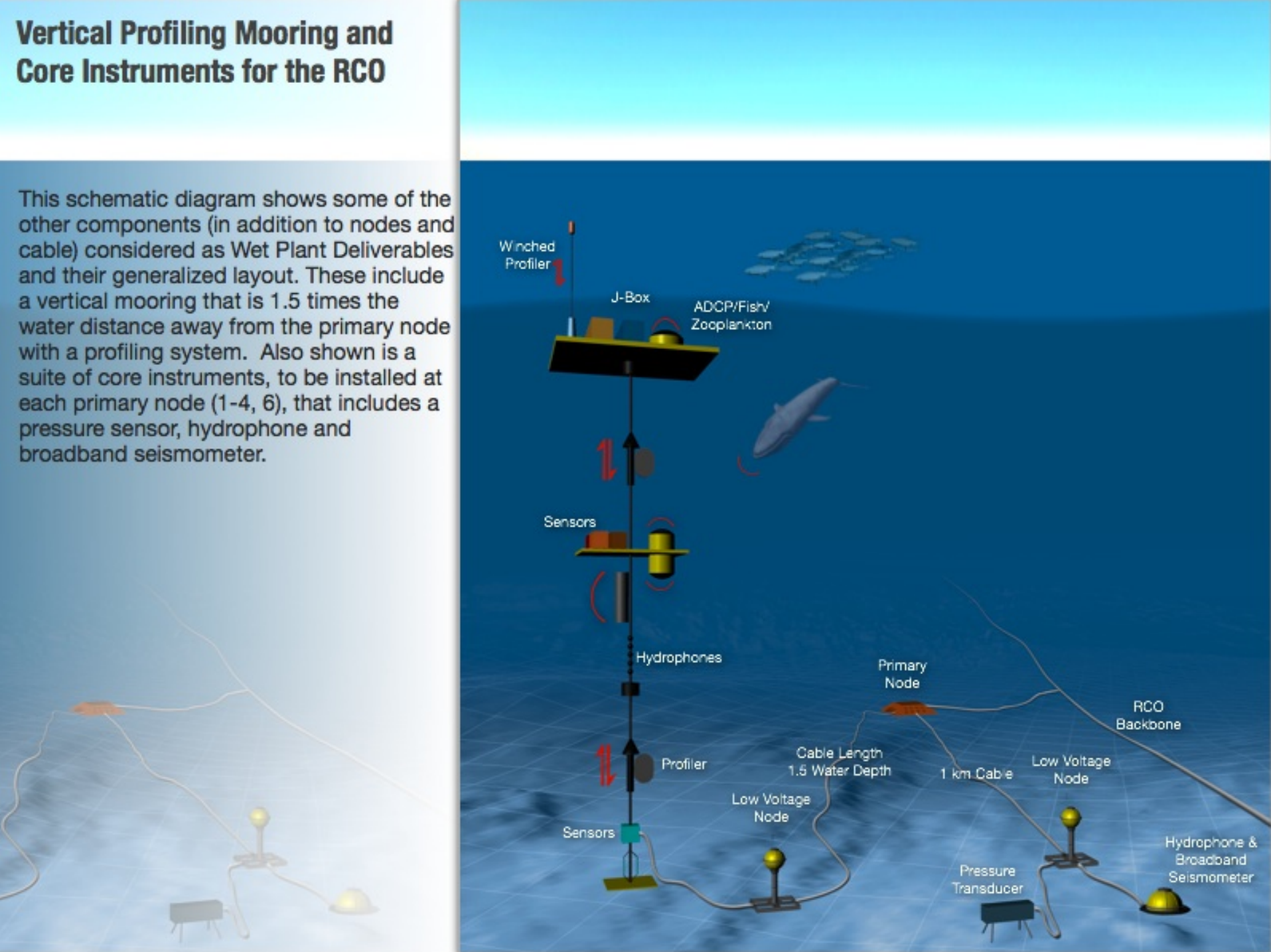
## linked by the internet

- 2000 Kms of electro-optical cable
- A network of submarine laboratories
- Next Gen Internet to the sea floor 10's Gb/sec
- 100 Kw Power on Grid
- Robotic interaction at speed of light
- 30 yr life-time


From J. Delaney - Univ of Washington, Seattle

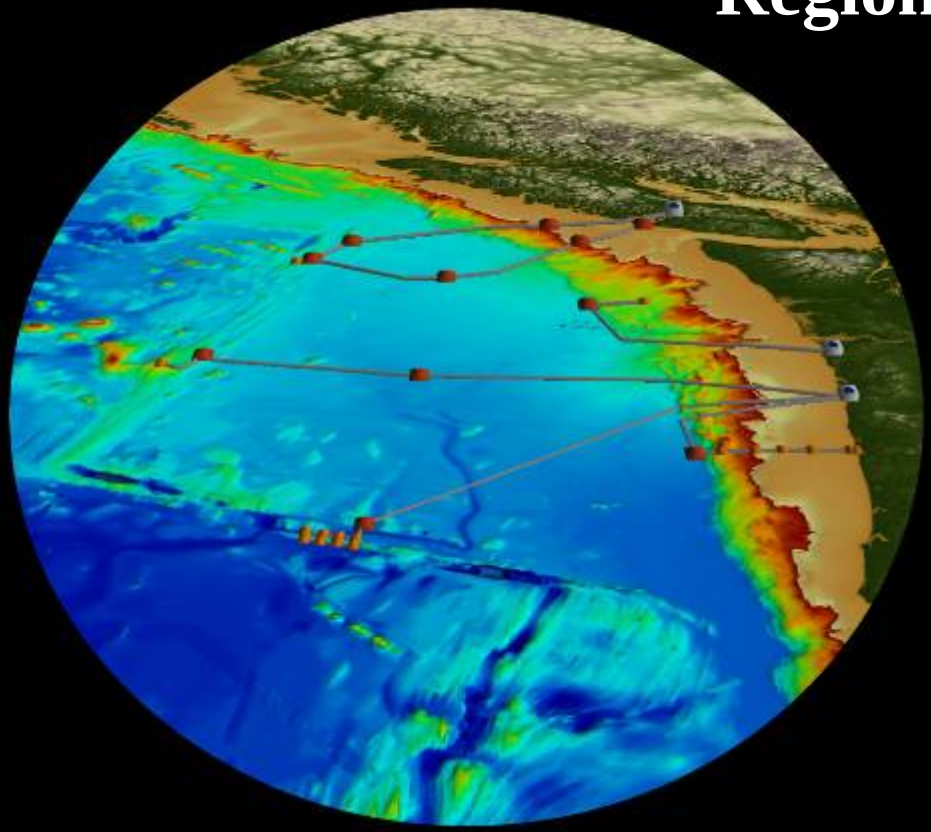
# Vertical Profiling Mooring and Core Instruments for the RCO

This schematic diagram shows some of the other components (in addition to nodes and cable) considered as Wet Plant Deliverables and their generalized layout. These include a vertical mooring that is 1.5 times the water distance away from the primary node with a profiling system. Also shown is a suite of core instruments, to be installed at each primary node (1-4, 6), that includes a pressure sensor, hydrophone and broadband seismometer.



# Data on the internet available to everyone !

# Regional Scale Node Considerations

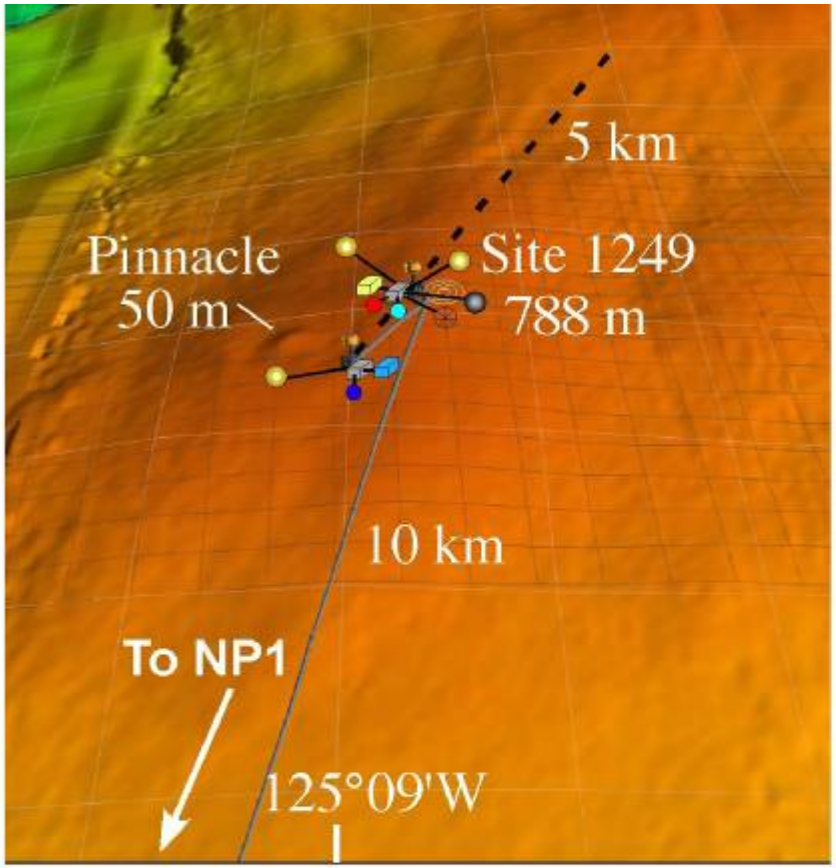


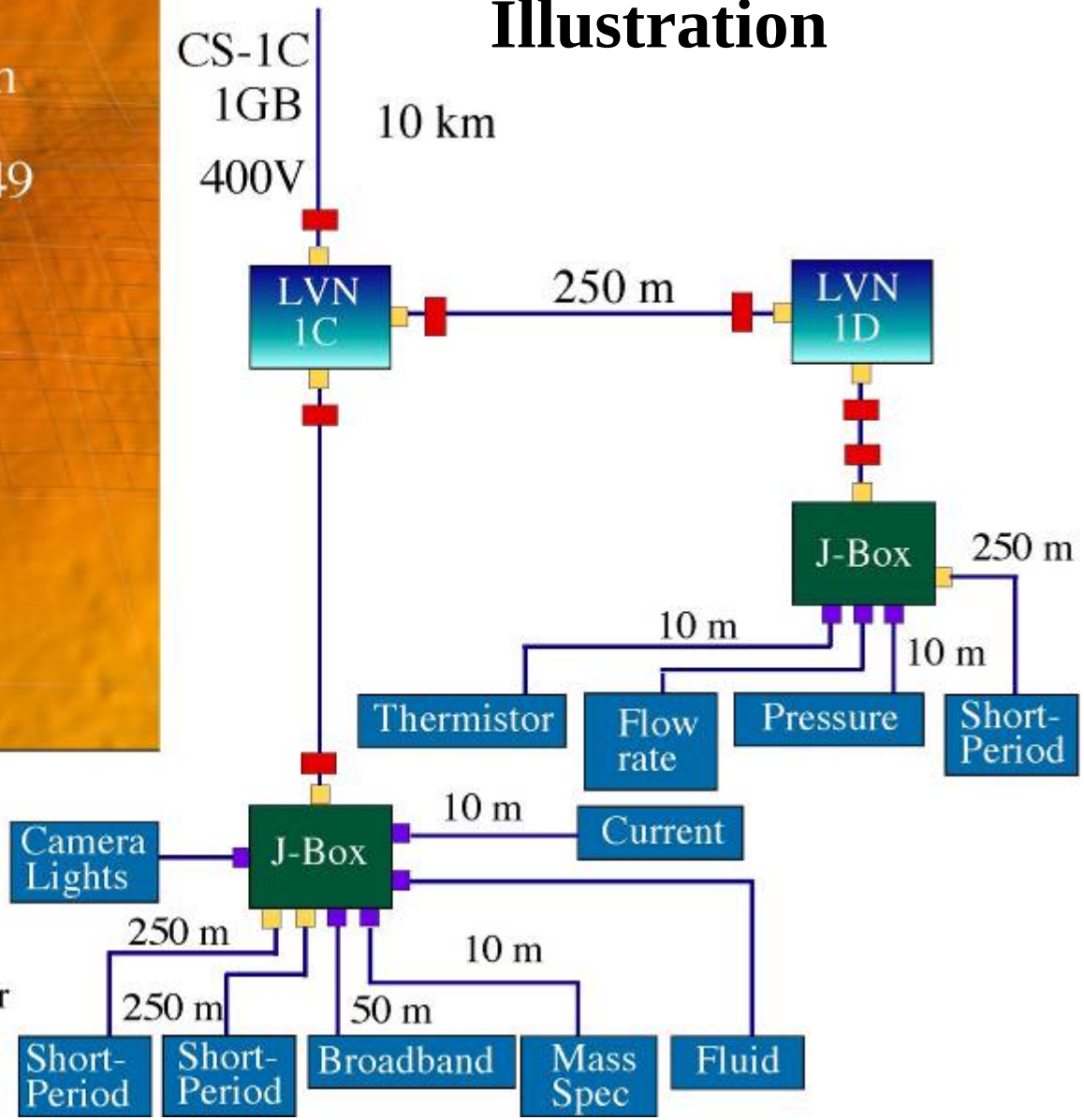
Costs
Risk
Functionality: geographic reach & expandability (both power & bandwidth)
Reliability: significant impact on both costs and functionality (faults)
Availability: a measure of "the time up"- desire continuous operation

Attributes:
- Utilizes repeaterless technology
- Each segment delivers 10 kilowatts (expandable)
- 10-Gigabit Ethernet (expandable)
- 400 volts at each node

Courtesy of D. Kelley (UW)

# Hydrate Ridge Infrastructure Illustration

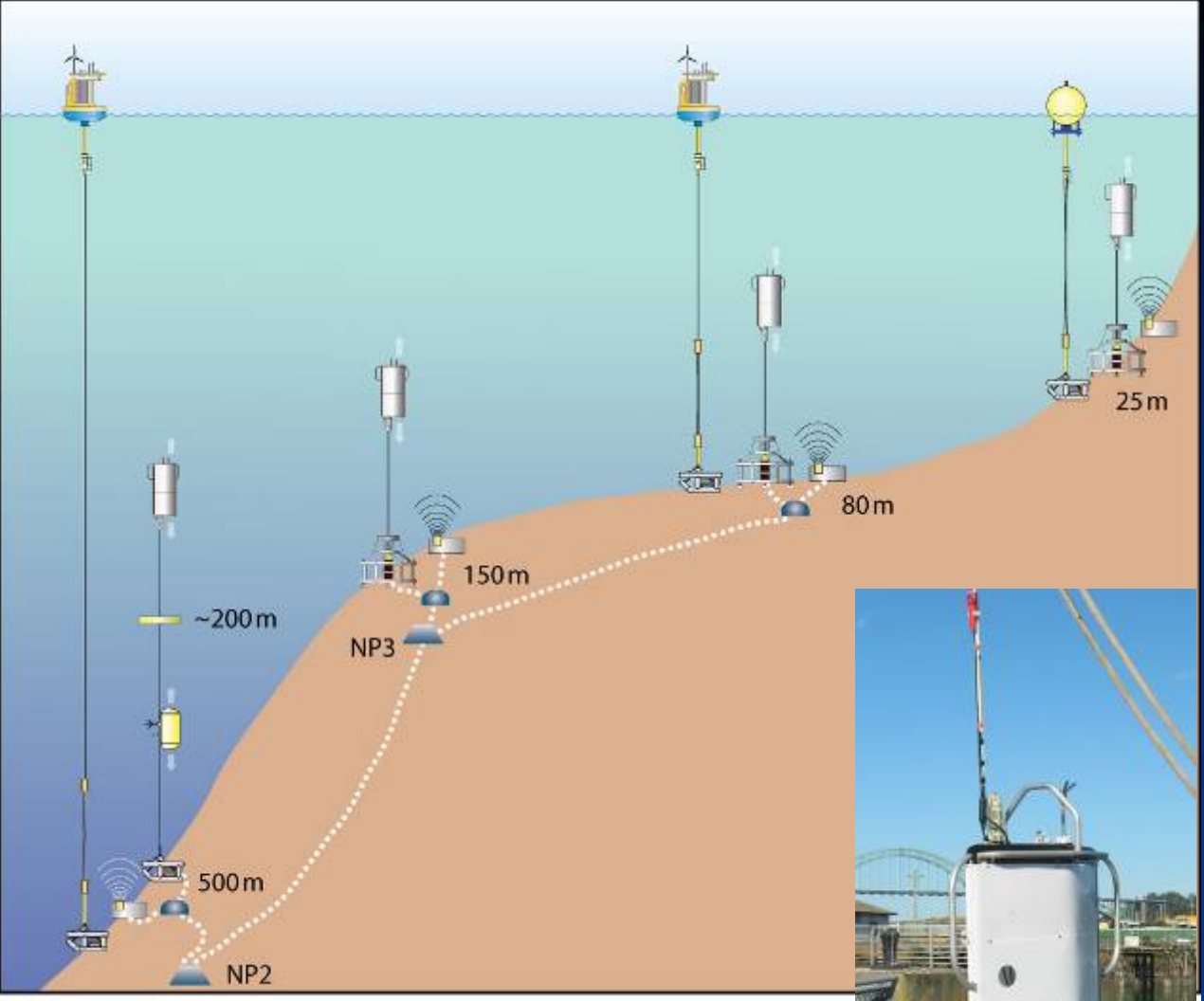


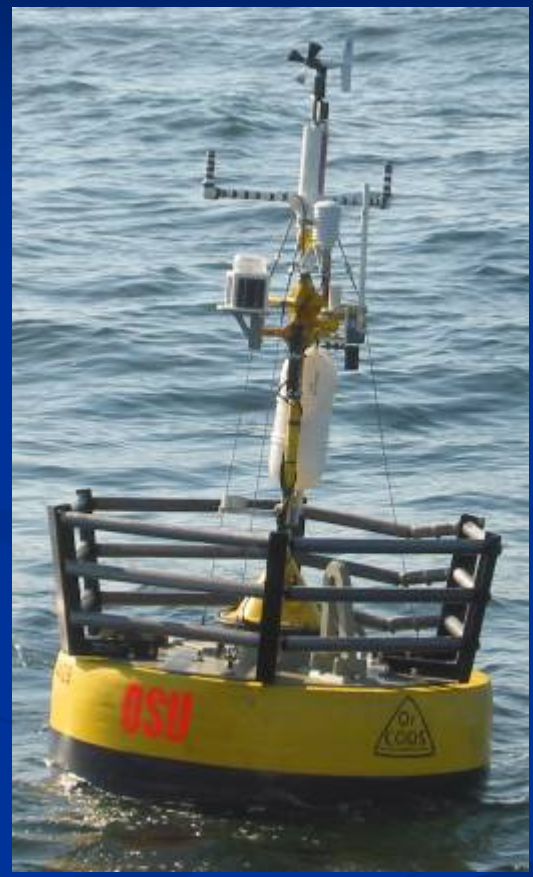

- Dry-Mate electrical connector
- Wet-Mate optical connector
- Wet-Mate 10kv electrical connector
- Wet-Mate electrical connector
- Electro-optical converter

Courtesy of D. Kelley (UW)

# Coastal Ocean Observing



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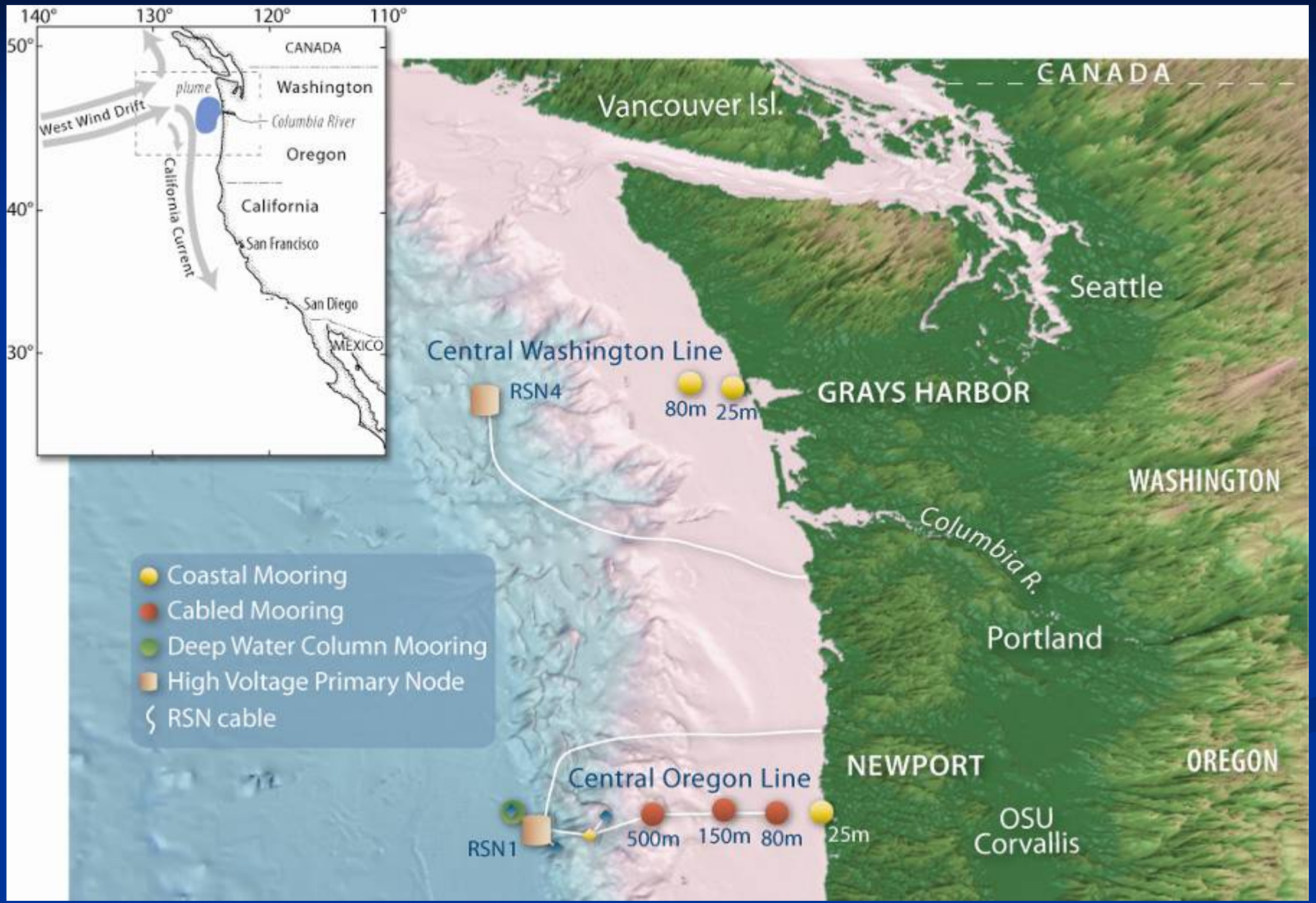
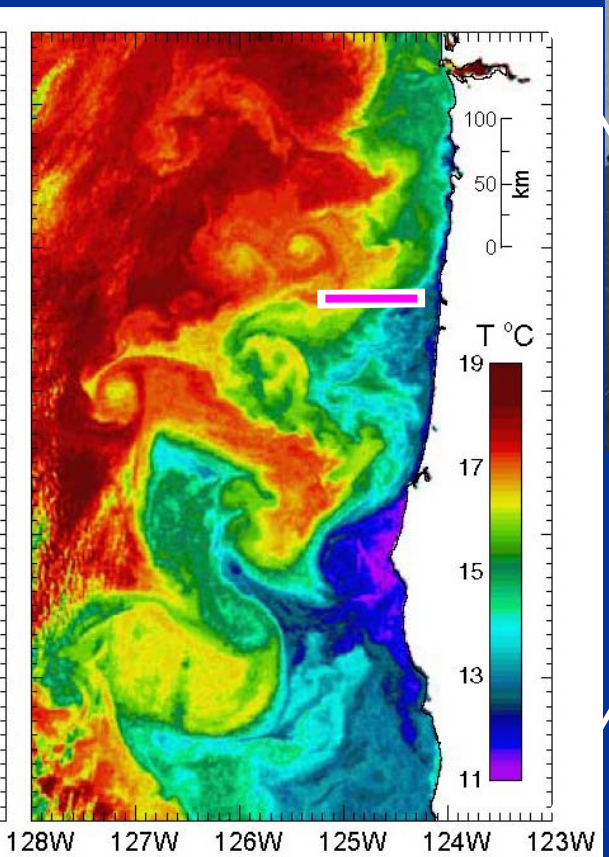
# The Pacific Northwest Endurance Array



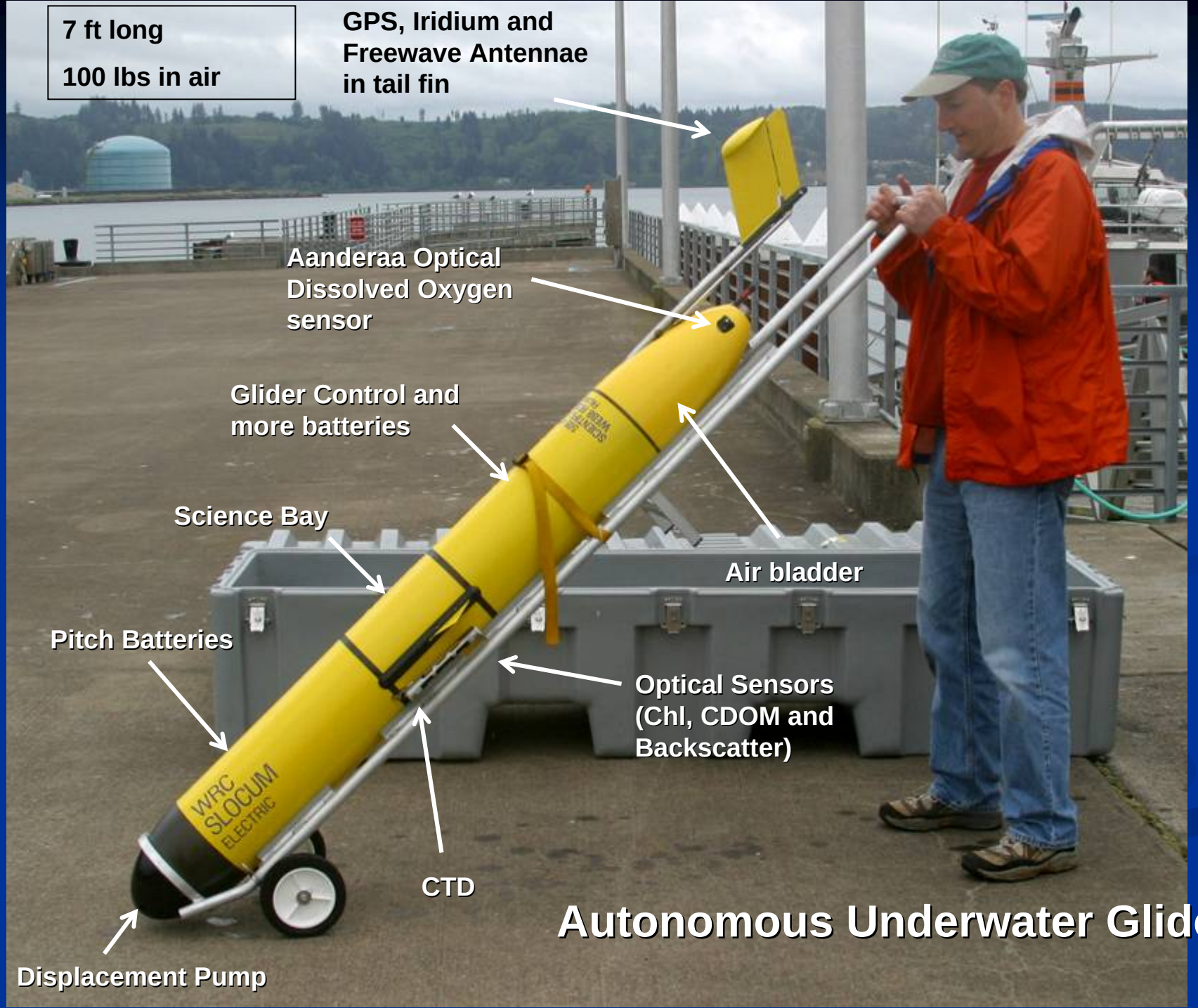
# Autonomous Underwater Vehicle Gliders

**cross-margin transect twice per week since April 2006**



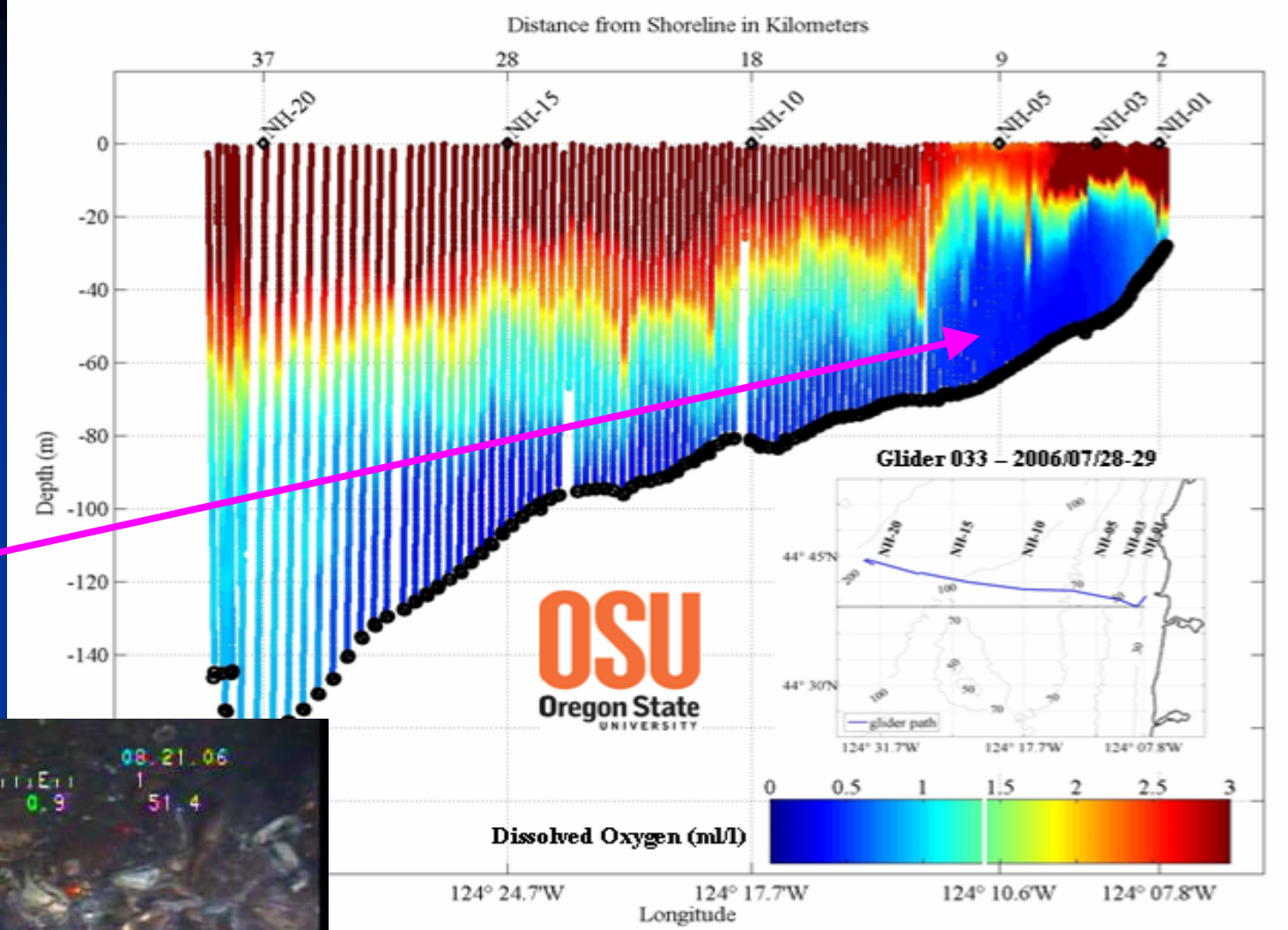


Barth/Shearman/Erofeev (OSU)


7 ft long
100 lbs in air
GPS, Iridium and Freewave Antennae in tail fin
Aanderaa Optical Dissolved Oxygen sensor
Glider Control and more batteries
Science Bay
Air bladder
Pitch Batteries
Optical Sensors (Chl, CDOM and Backscatter)
CTD
Displacement Pump
WRC SLOCUM ELECTRIC
Autonomous Underwater Glider

# Autonomous Underwater Vehicle Gliders

Hypoxia


OSU
'GO DUCKS'
OREGON STATE UNIVERSITY
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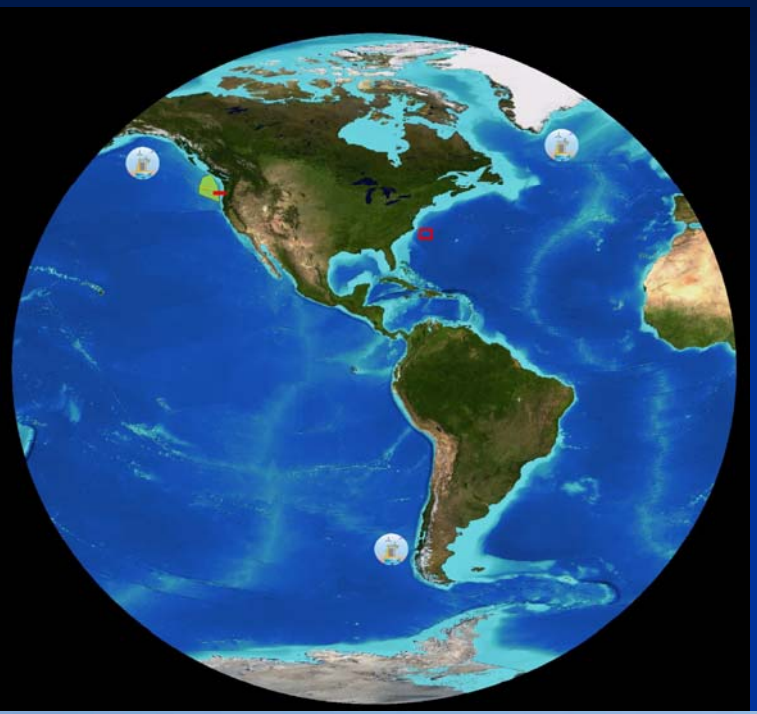
Beavers

# Ocean Observatories Initiative



## Next Steps

- Finalize Science Prospectus
- Continue instrument and network development
- Continue to talk with Oregon ocean users
- Optimize cable and node placement

# EXTRAS

# BASIC POINTS of the TALK

The oceans are central to quality of life on earth.

They are mysterious, dangerous, ...and unexplored.

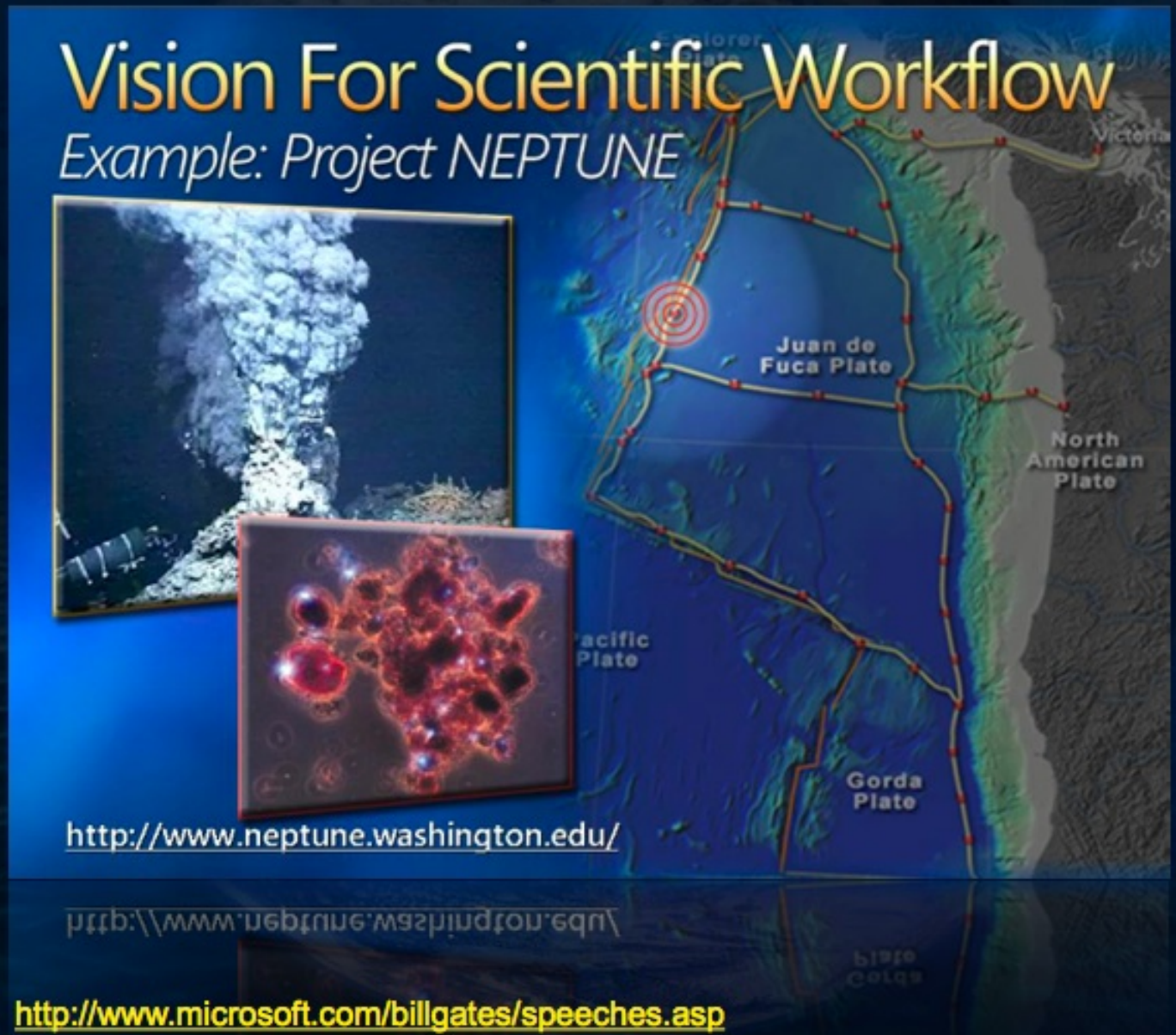
We must understand processes operating in the ocean basins to understand planetary ecosystems.

There are bold, new approaches to studying oceans.

These approaches will revolutionize the way humans perceive (and eventually manage...) their entire planet .

# Ocean observing and its cyberinfrastructure needs have been noticed …

# From Bill Gates' speech …




http://www.microsoft.com/billgates/speeches.asp