



Oceans are complex and are relatively
unexplored

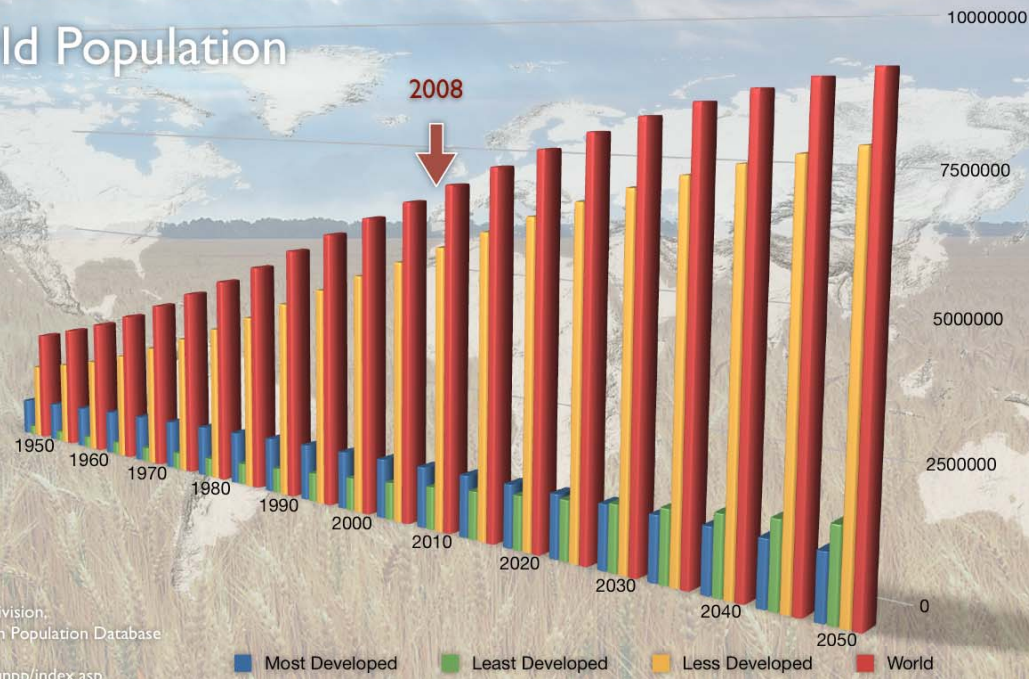
Oscar Schofield

RU COOL

<http://rucool.marine.rutgers.edu>

I want to thank ocean leadership for the opportunity to speak, also i greatly appreciate the support of NSF and the efforts of the review committee. The ocean community has for over a decade been designing and iterating on a distributed

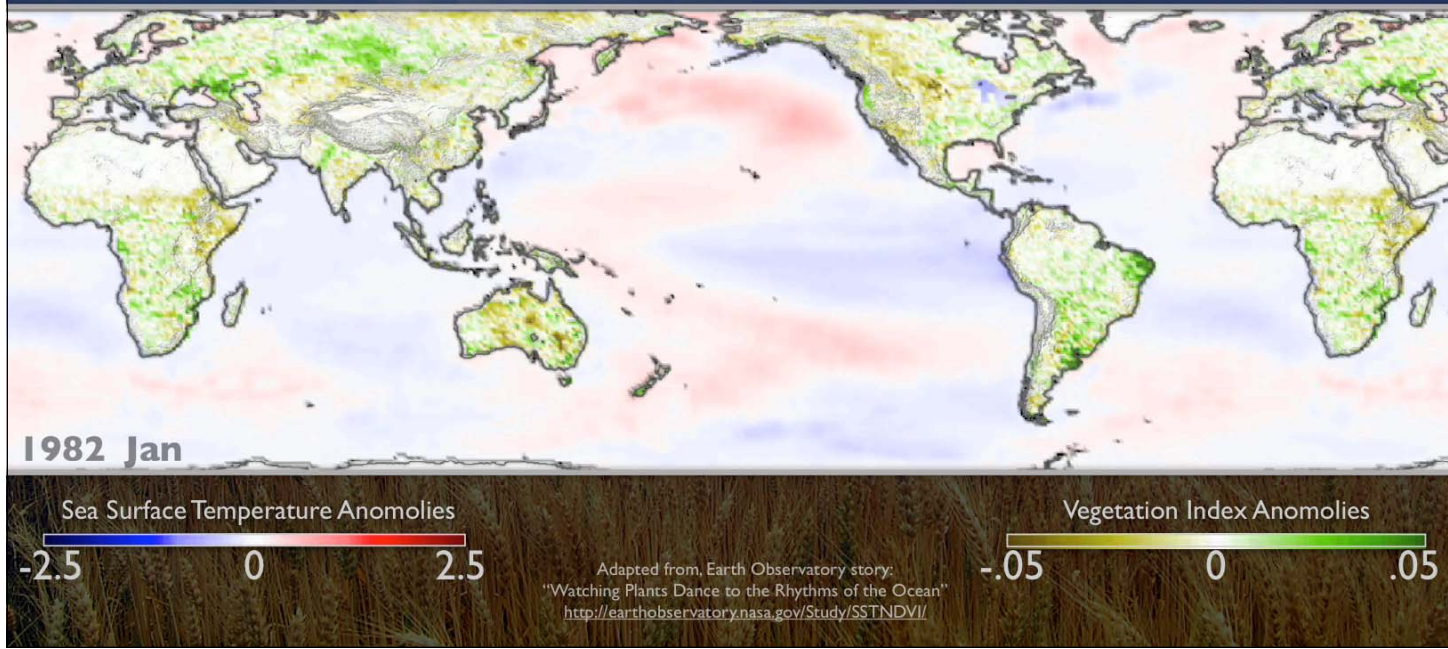
World Population



Data Source:
UN Population Division,
The 2006 Revision Population Database
Medium Variant
<http://esa.un.org/unpp/index.asp>

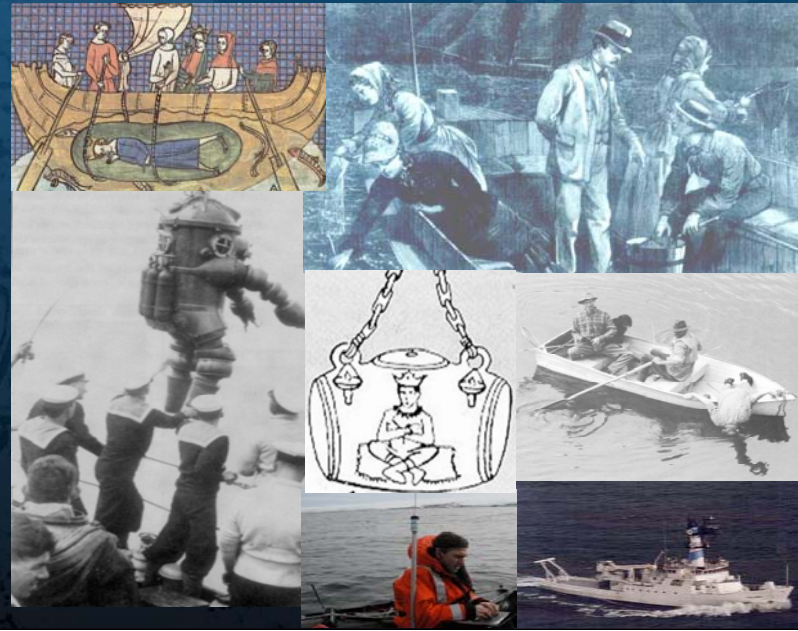
■ Most Developed ■ Least Developed ■ Less Developed ■ World

The Ocean is linked to plant growth on the continents



Humans sample the ocean poorly

THE OLD WAYS





Scientists have a **hard**
time sampling the **oceans**

Difficult & dangerous to
observe or interact with.

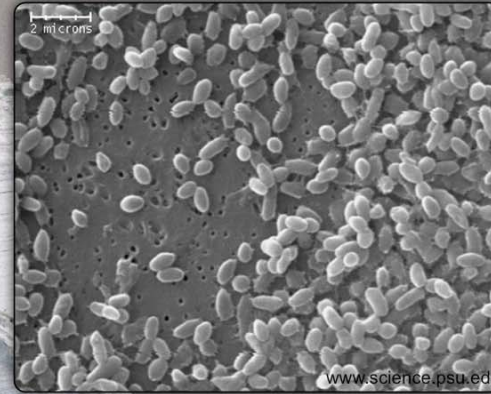


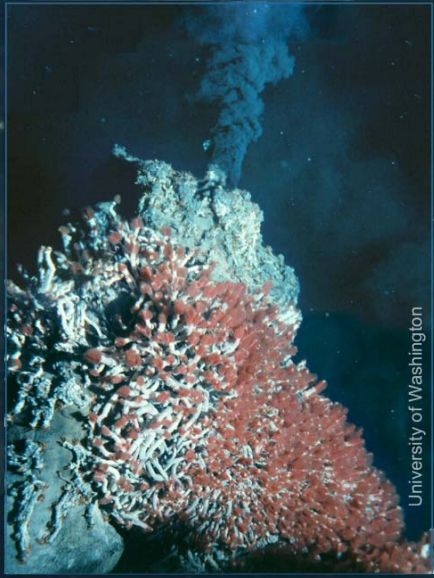
Oceans destroy infrastructure and very little can survive the unique stresses that the ocean delivers.



upload.wikimedia.org/wikipedia/commons/9/97/Corrosion.jpg

Many aspects of
the ocean are
understudied
such as cold
oceans and
undiscovered biota





University of Washington

Humans rarely get to study extreme environments, extreme conditions on and in the seafloor

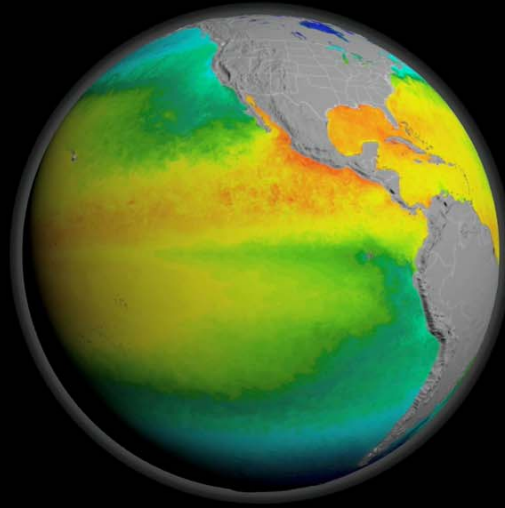
Our Challenge:
To optimize the benefits
and mitigate the risks of
living on a planet driven by
two basic energy sources



Driven by
the sun



MODIS Sea Surface Temperature from 2002 to 2006



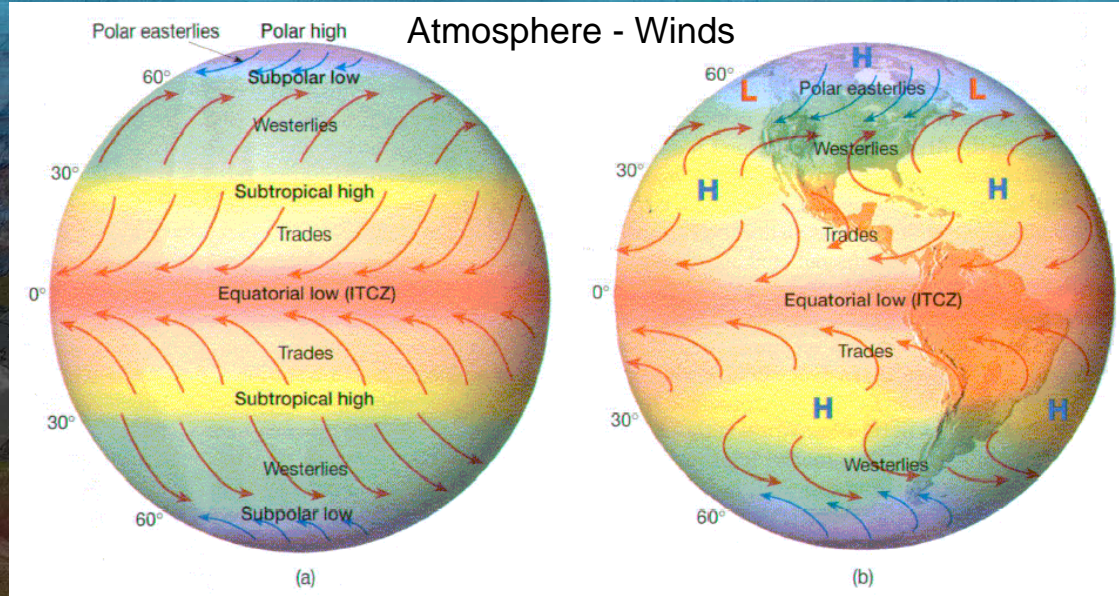
svs.gsfc.nasa.gov

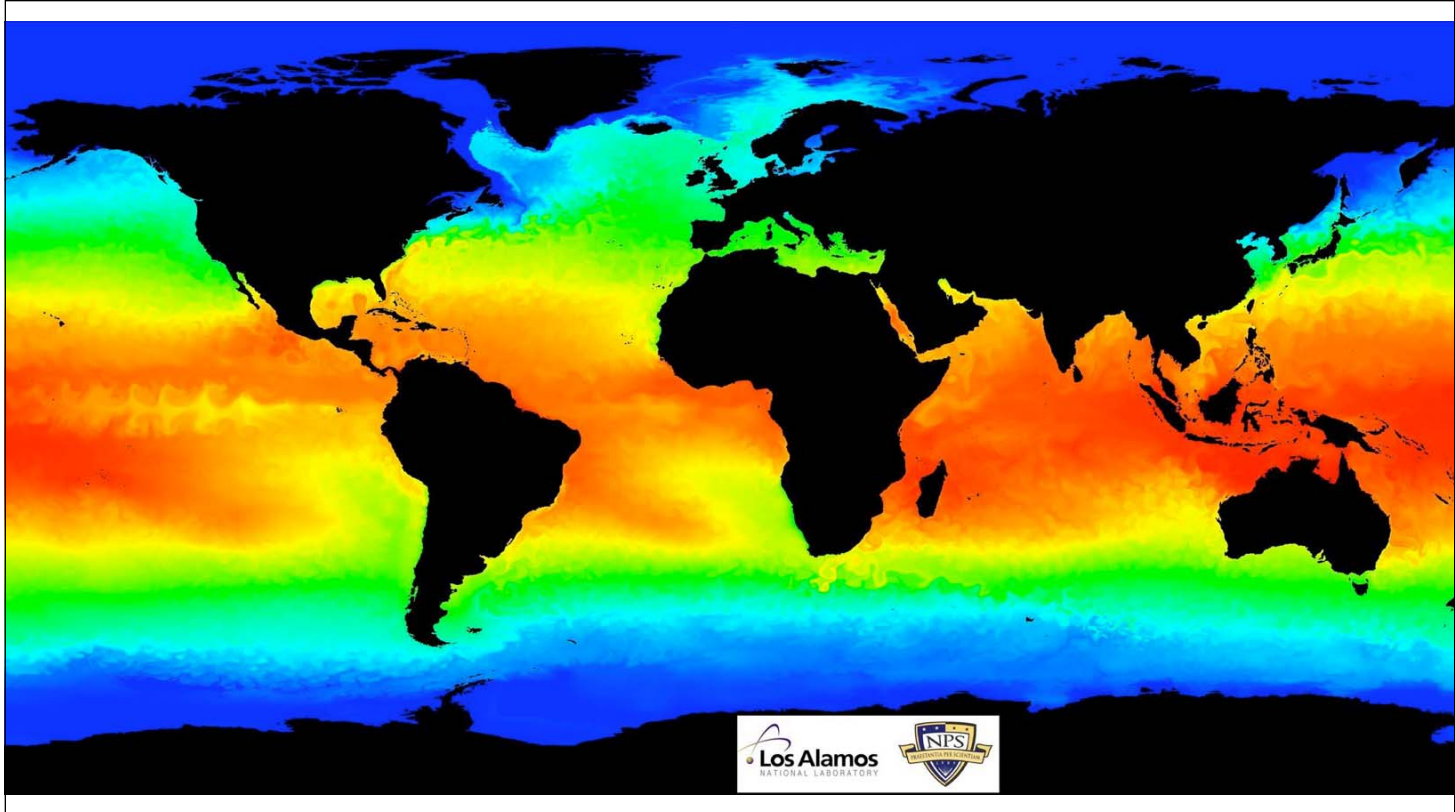
The sun heats the Earth at equator.

The planet cools at the poles.

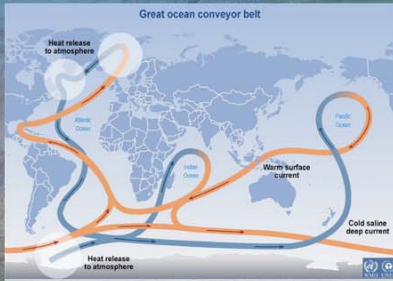
The ocean stores and transfers heat.

Atmosphere - Winds



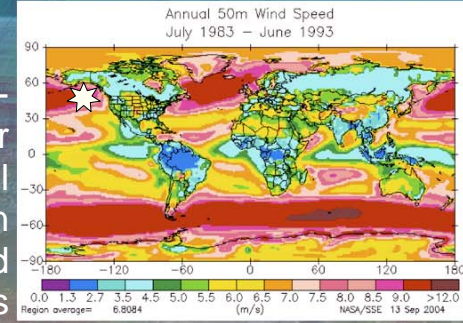


- **Oceans Strongly Driven By Atmosphere - Solar Heat, Fresh (Rain) Water, Heavy Winds, Air-Sea Gas Exchange)**
- **Maximum Impact High Latitudes and Equator.**

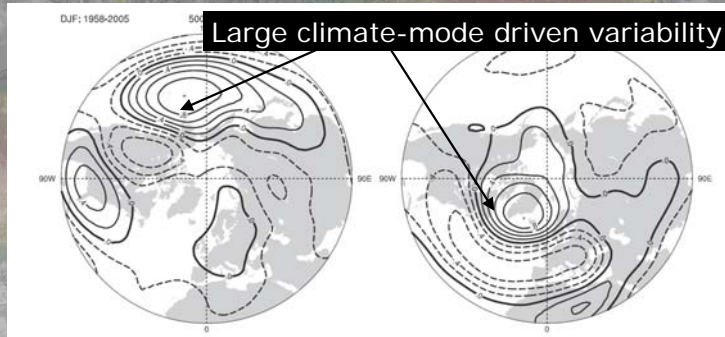


Heat loss, formation of interior water masses

Ten-year global mean wind speeds



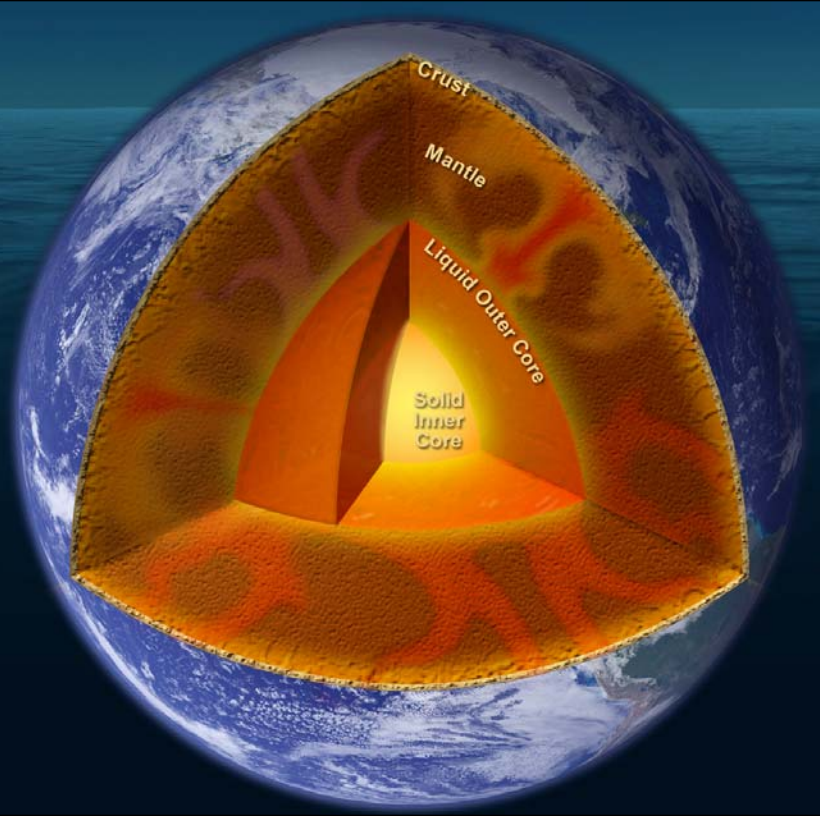
Energetic wind/wave forcing



The Pacific Decadal Oscillation (PDO) and North Atlantic Oscillation (NAO), are **major climate impacts in Northern Hemisphere.**

Maximum wind variability **at OOI locations**, strongly impacts atm-ocean exchange - forcing dramatic physical, chemical, and biological variations.

Driven by
interior heat



Oceans Strongly Coupled to the Atmosphere

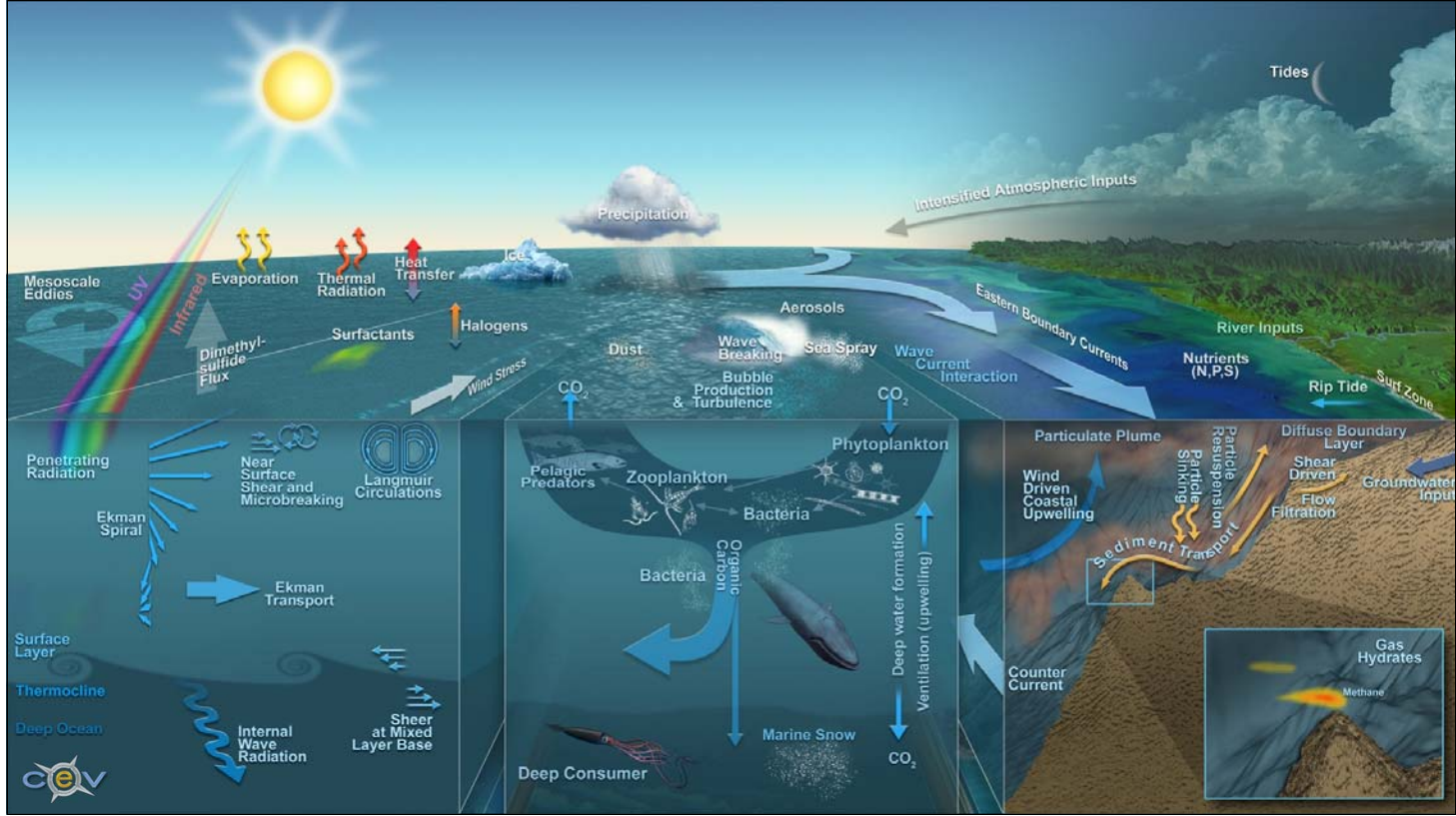
Asymmetry: Heating Equator/Cooling Poles

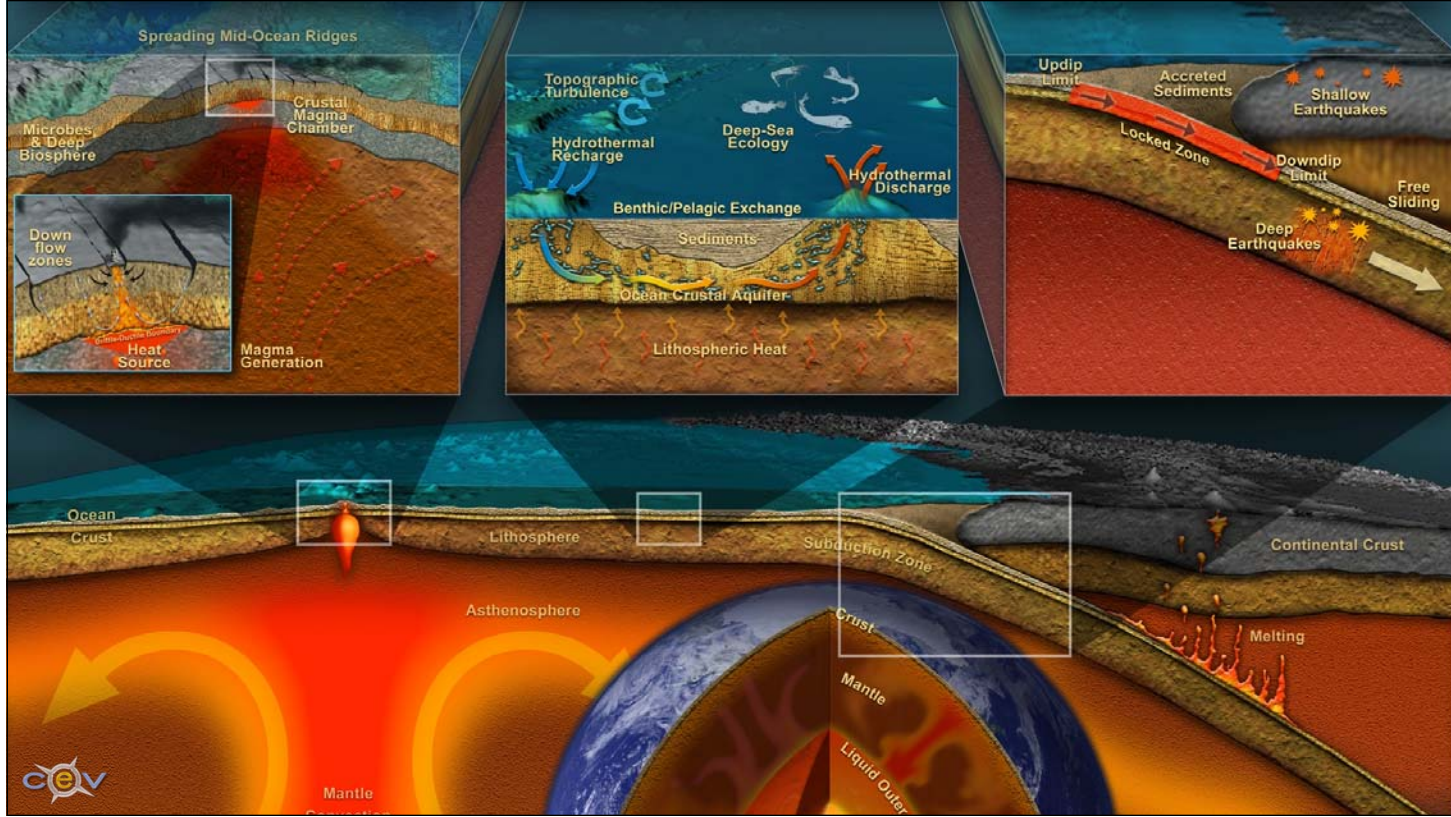
Earth Rotation + Continental Bounds on Basin
Geometry Leads to Wind-Driven Gyres

Exchange Driven by Large Climate-mode variability

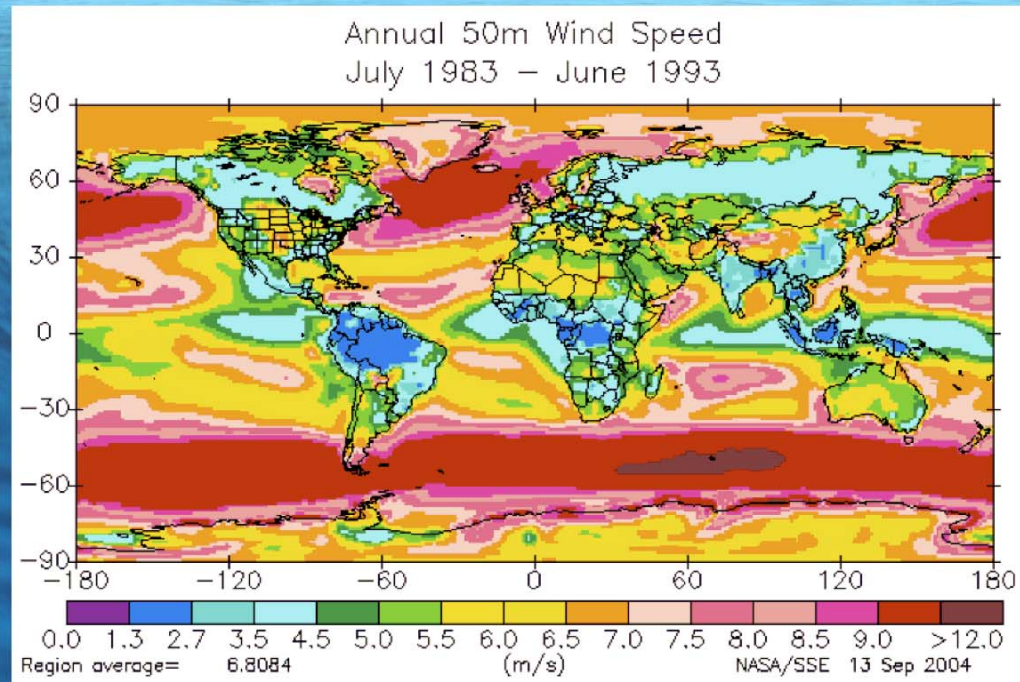
Maximum Impact High Latitudes and Equator.

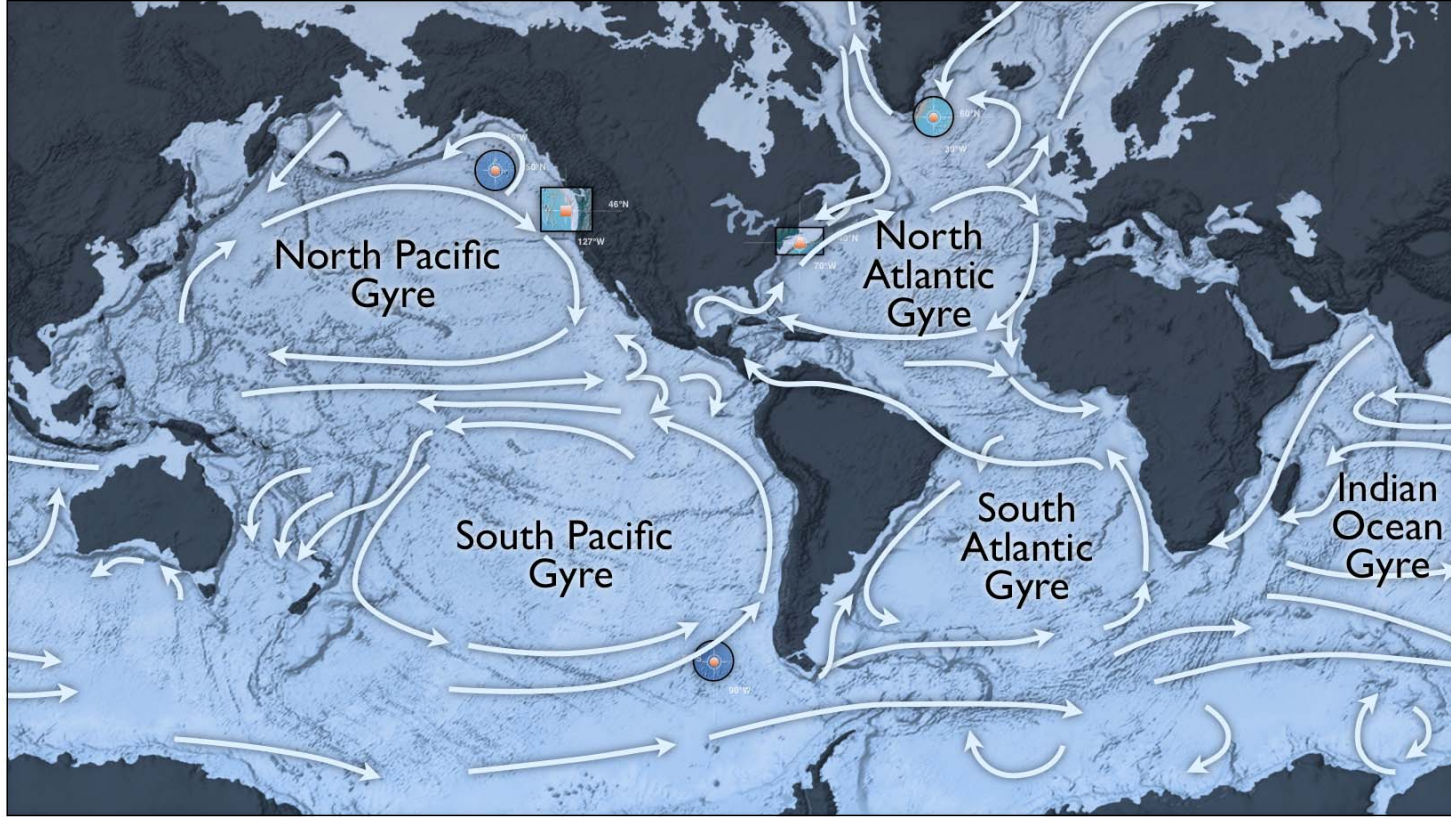
Formation of Deep and Intermediate Water - “Conveyor
Belt” - Thousand year cycle.

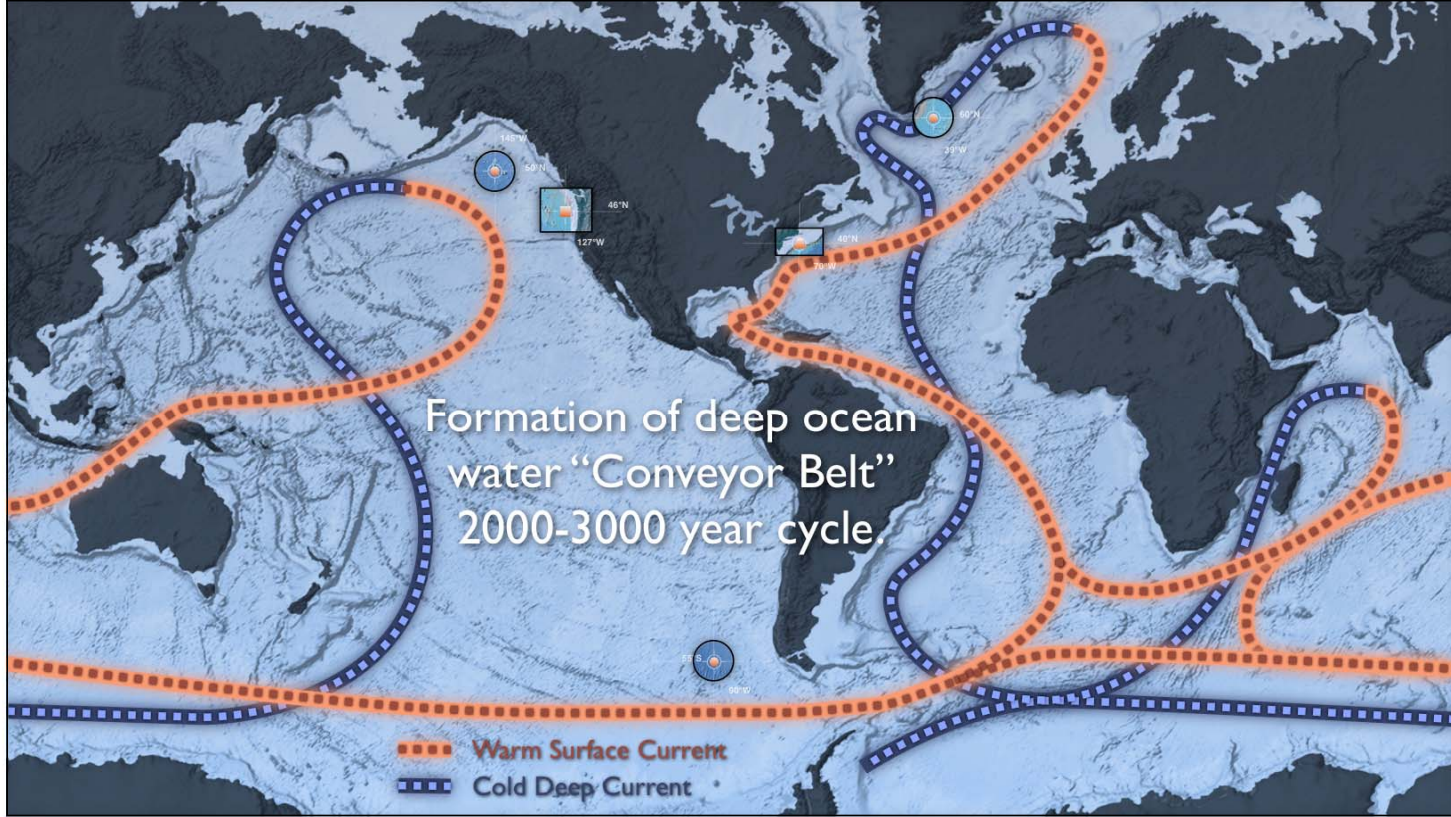




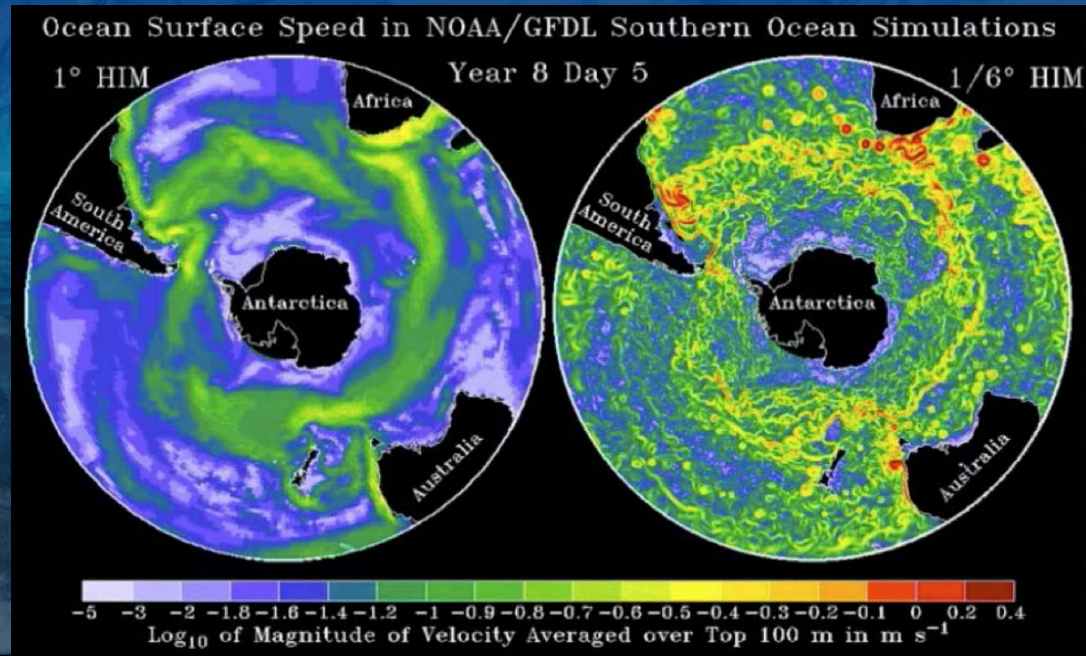
High latitudes- strongly forced, poorly observed

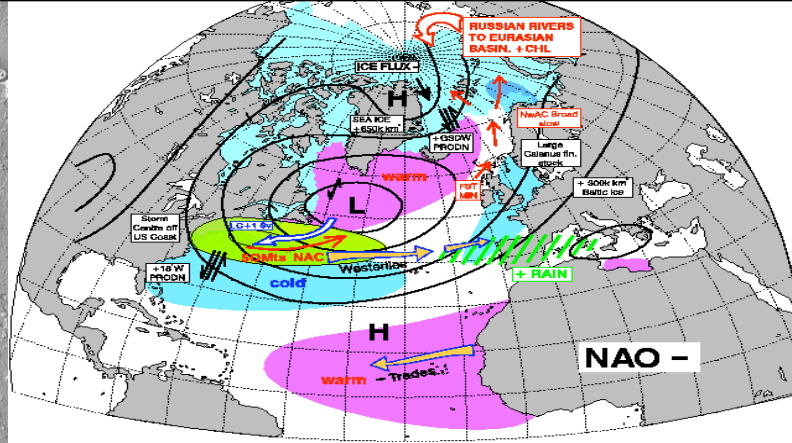




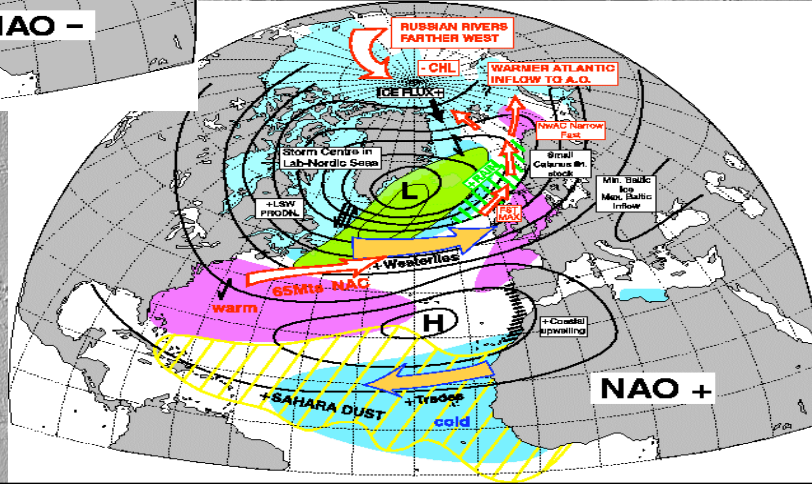


The success at understanding the large scale depends on resolving the mesoscale

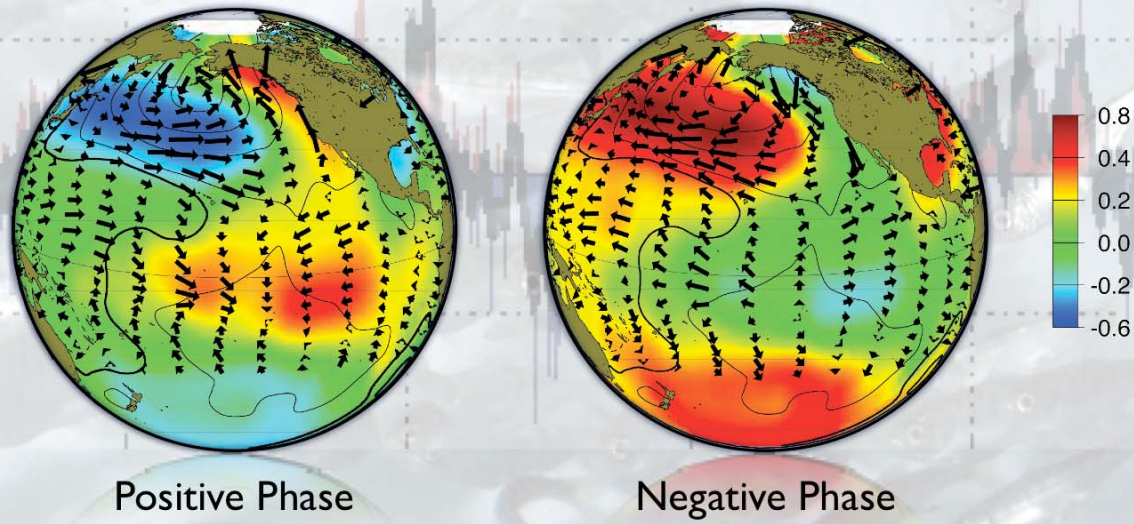




Climatic modes such as NAO have large (~basin) scale modes of coupled ocean and atmosphere variability

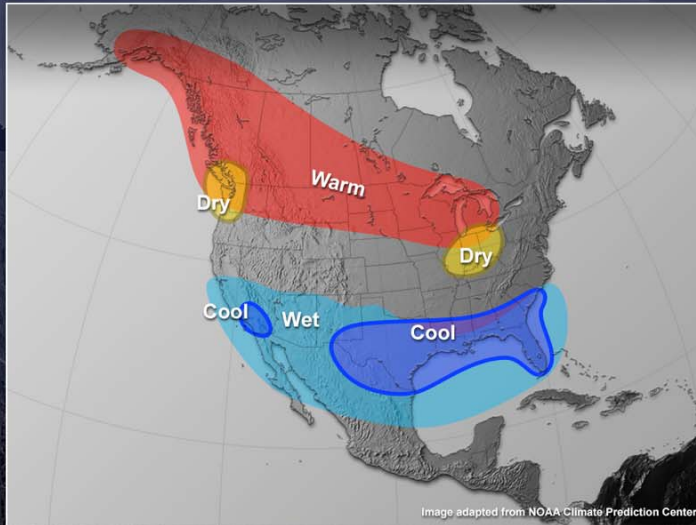


Pacific Decadal Oscillation

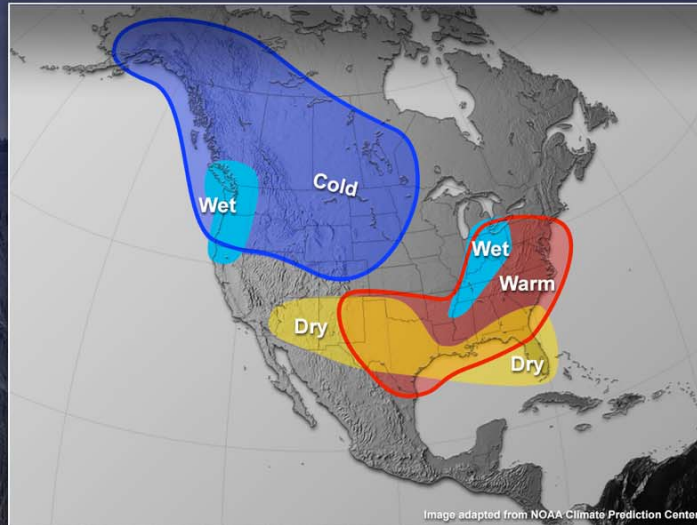


Source of PDO Images: Nate Matua 2000

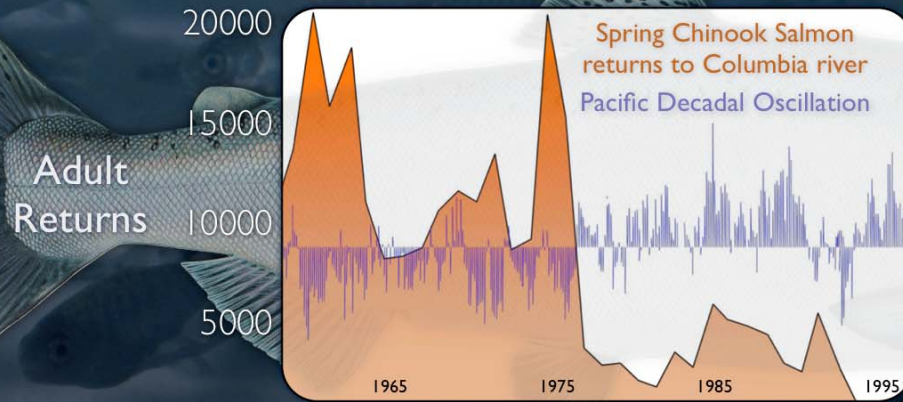
El Nino



La Nina

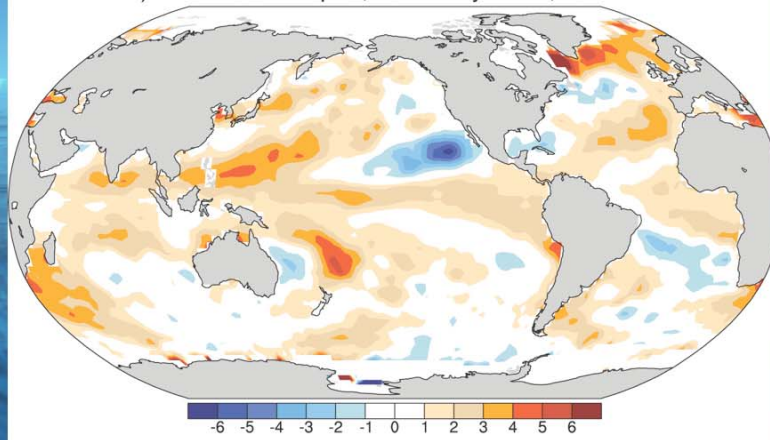


Pacific Decadal Oscillation

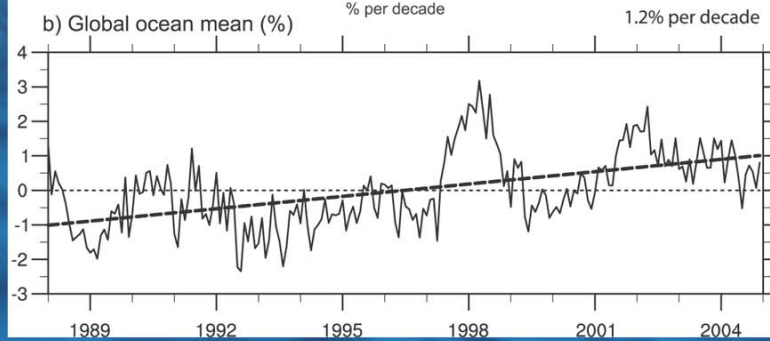


Graph adapted from: Manuel Barange, GLOBEC

a) Column Water Vapour, Ocean only: Trend, 1988-2004

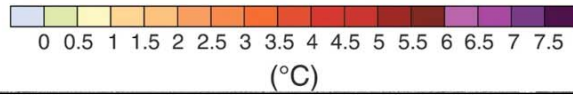
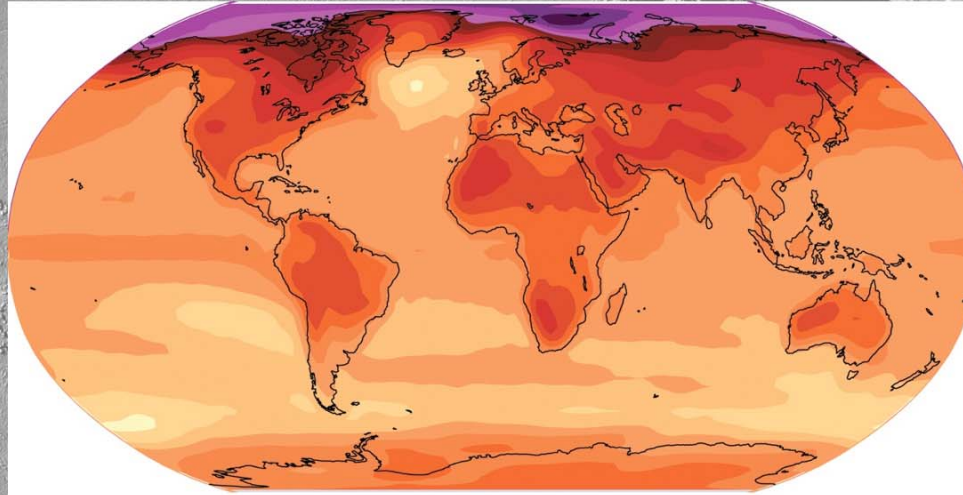


b) Global ocean mean (%)

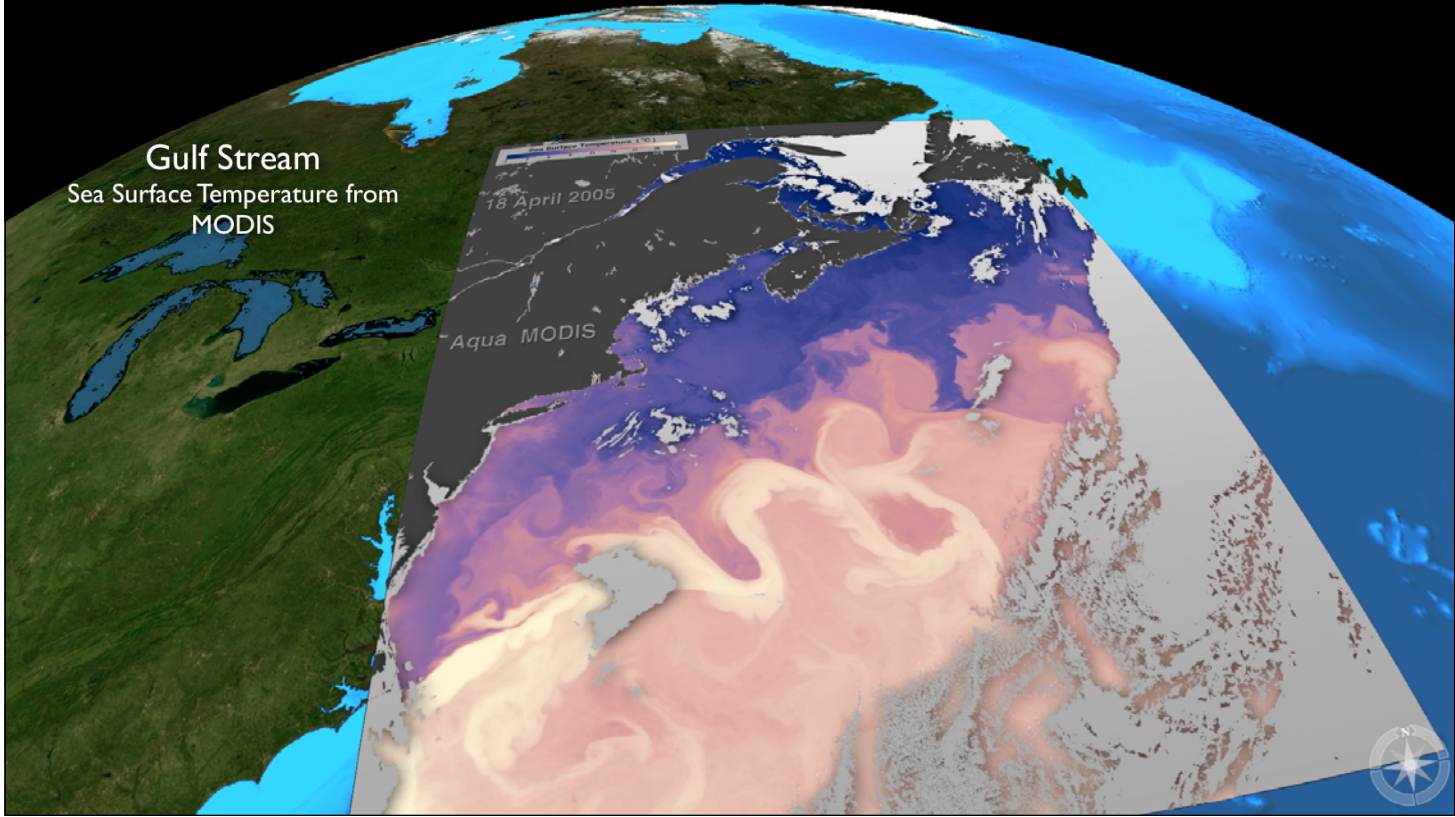


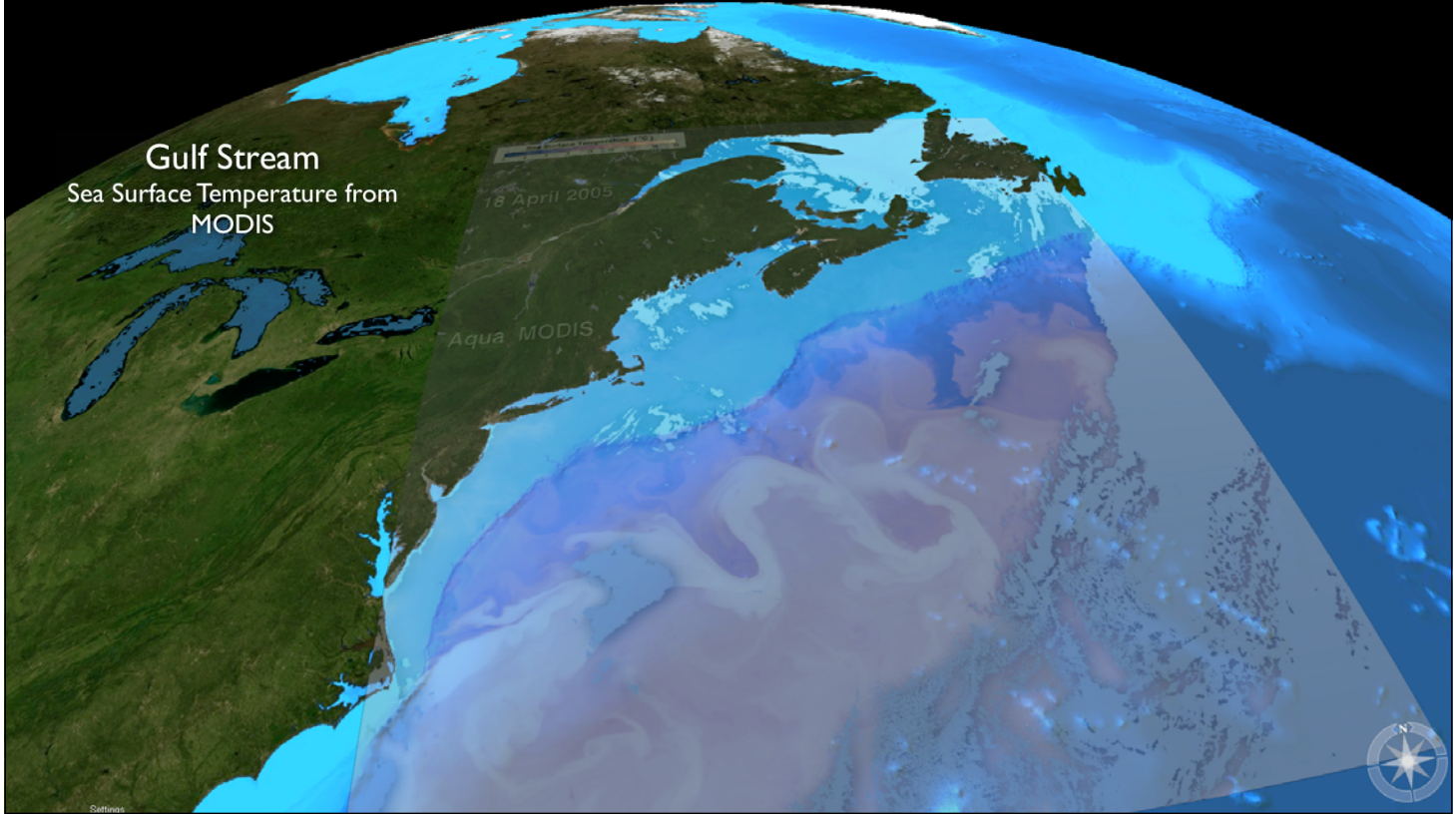
Long term
trends in the
ocean and in
the
atmosphere:
coupled?
feedbacks?

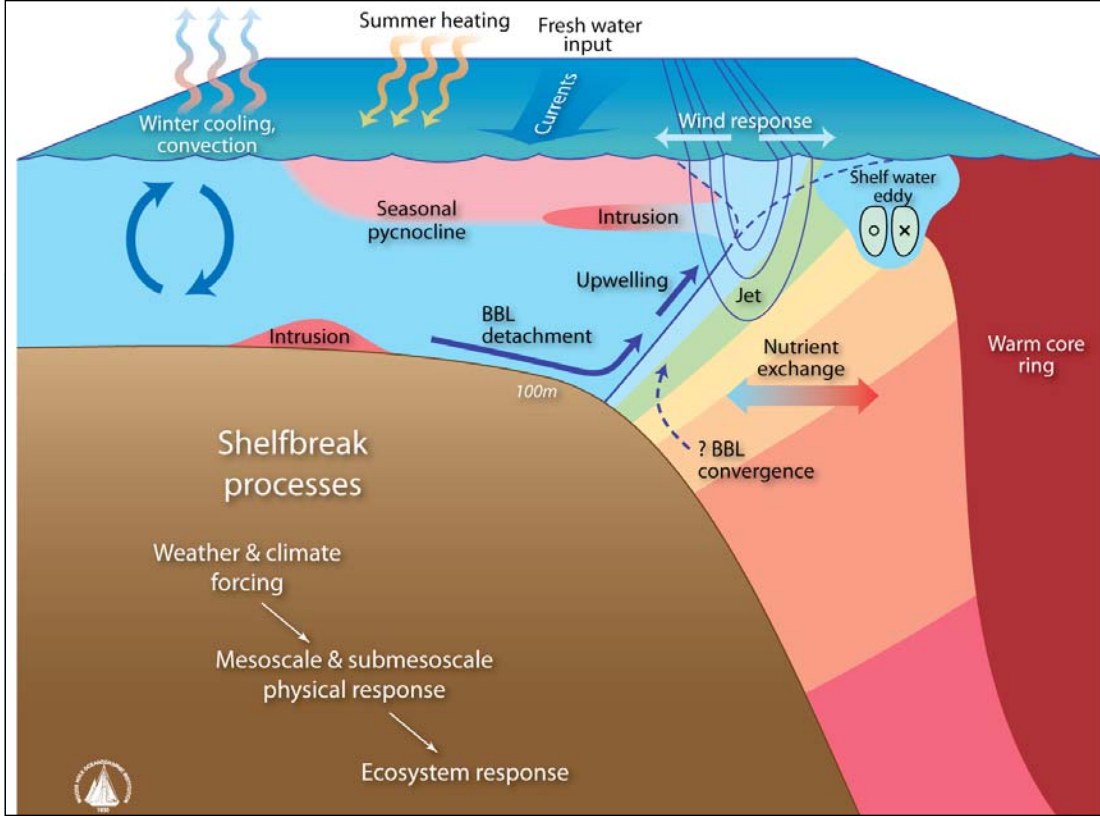
IPCC projection of surface temperature change (2090-2099 wrt 1980-1999)



scenario A1B

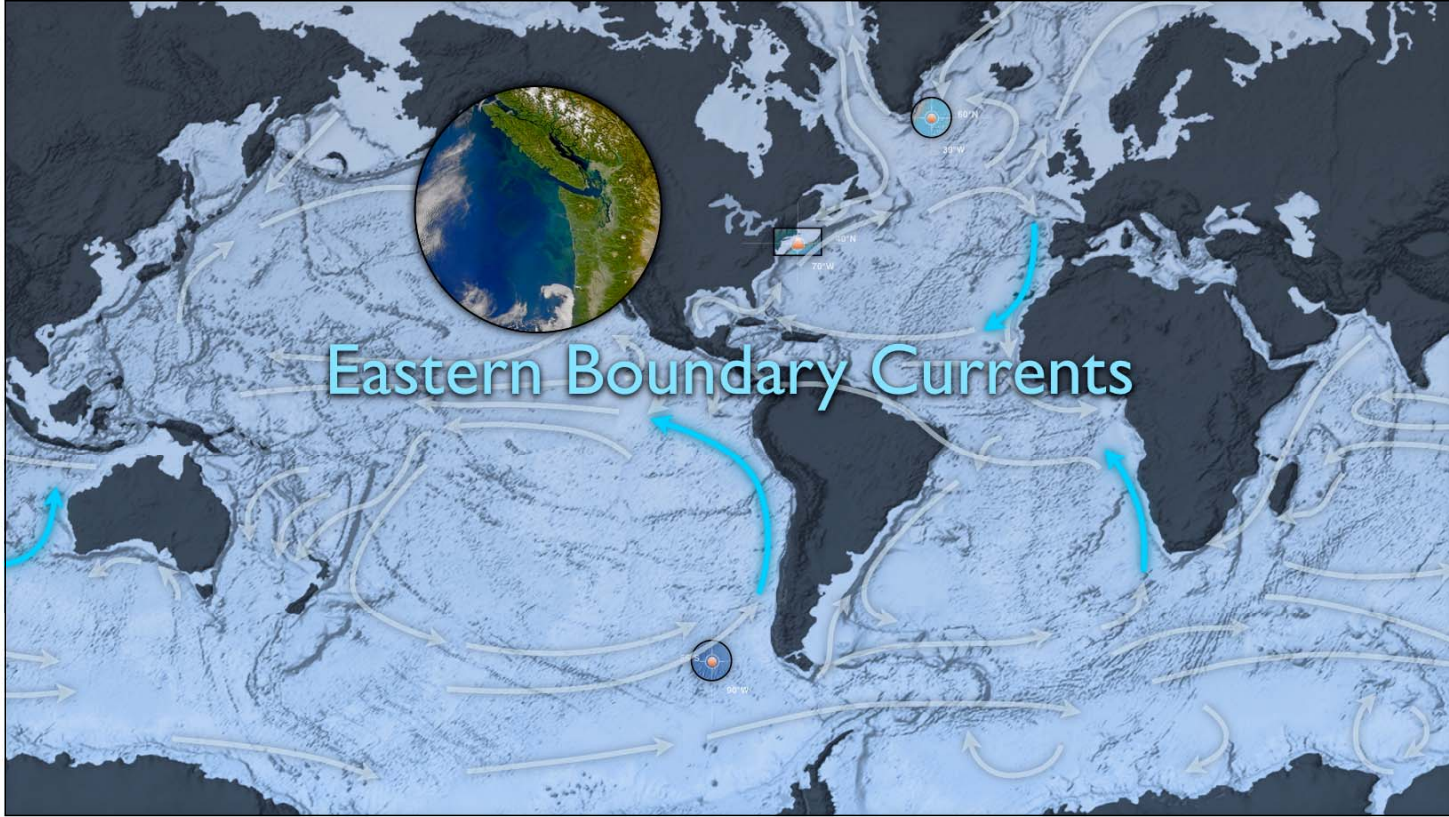




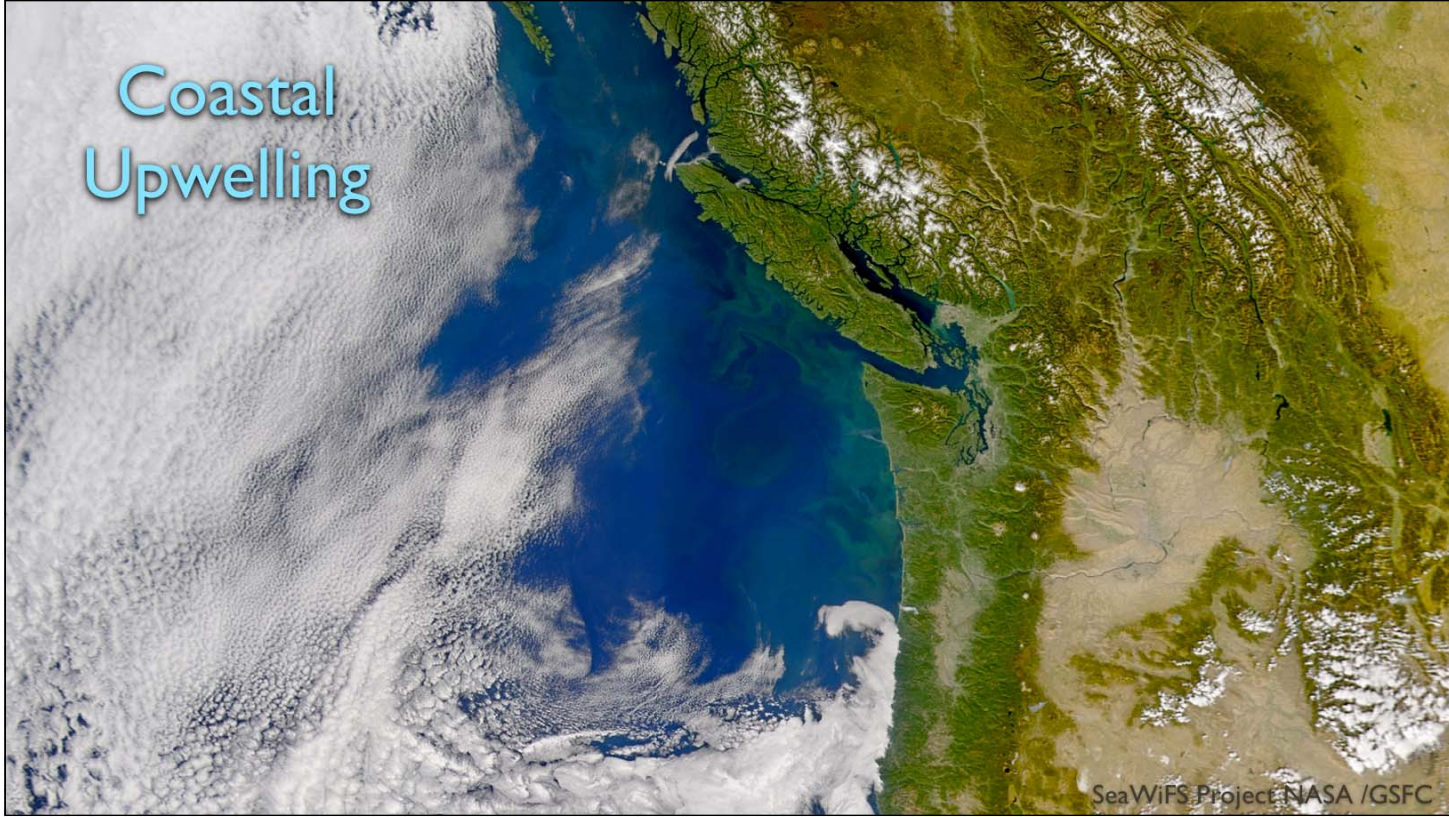


Processes governing exchanges across the shelf break front must be understood

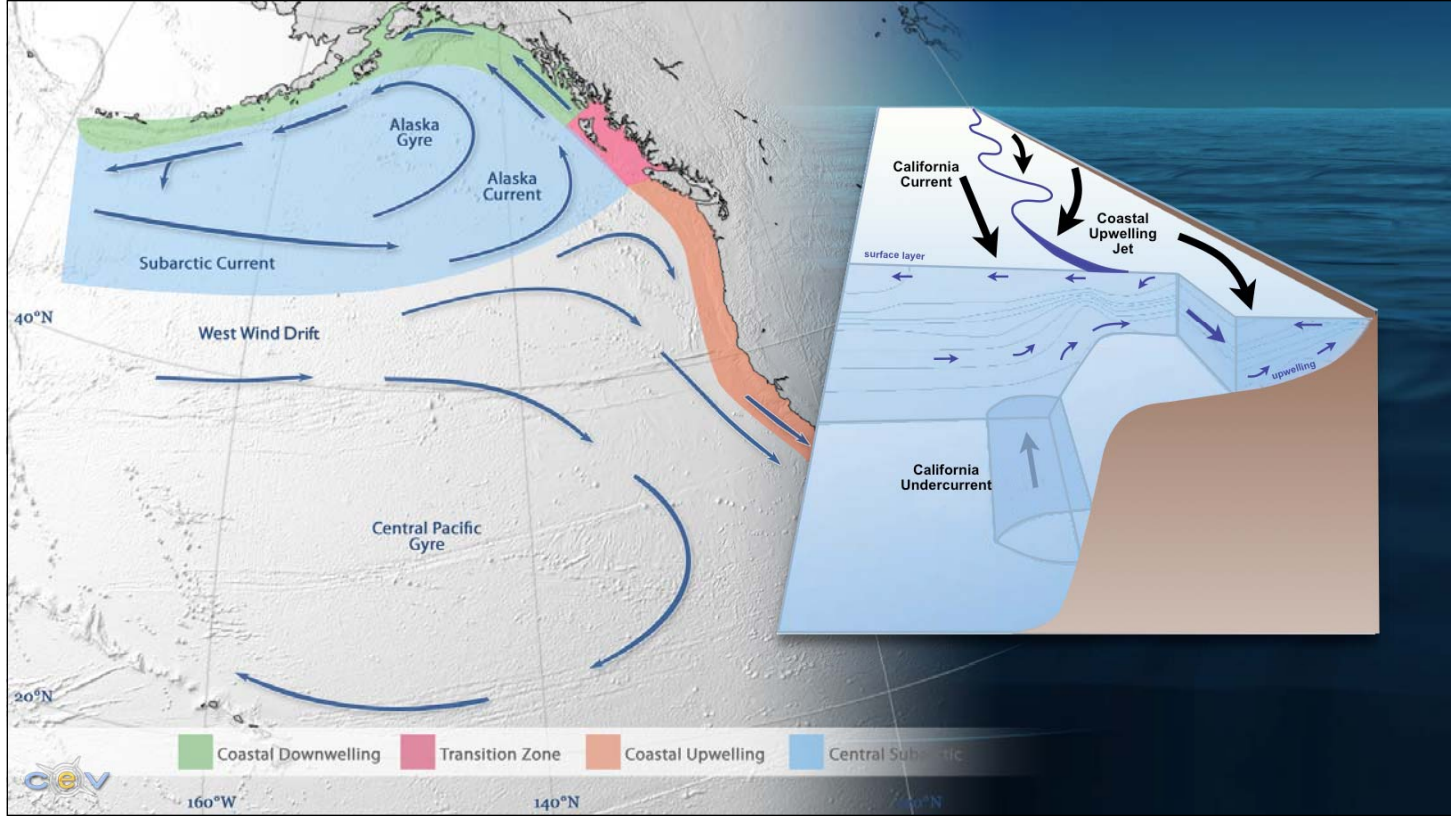




Coastal Upwelling

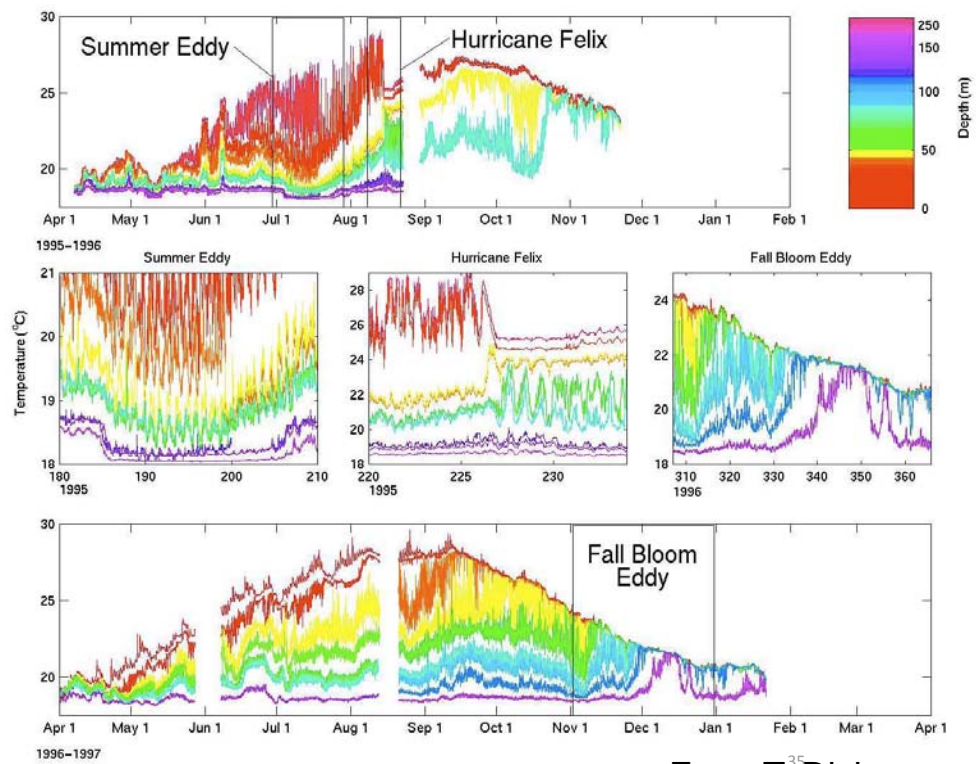


SeaWiFS Project NASA /GSFC



Transients -

- forcing and response
- nonlinearities
- lower period variability as the sum of events



From T. Dickey



Internal Heat Drives Plate Tectonics

Linked to:

The Shape of Ocean Basins;

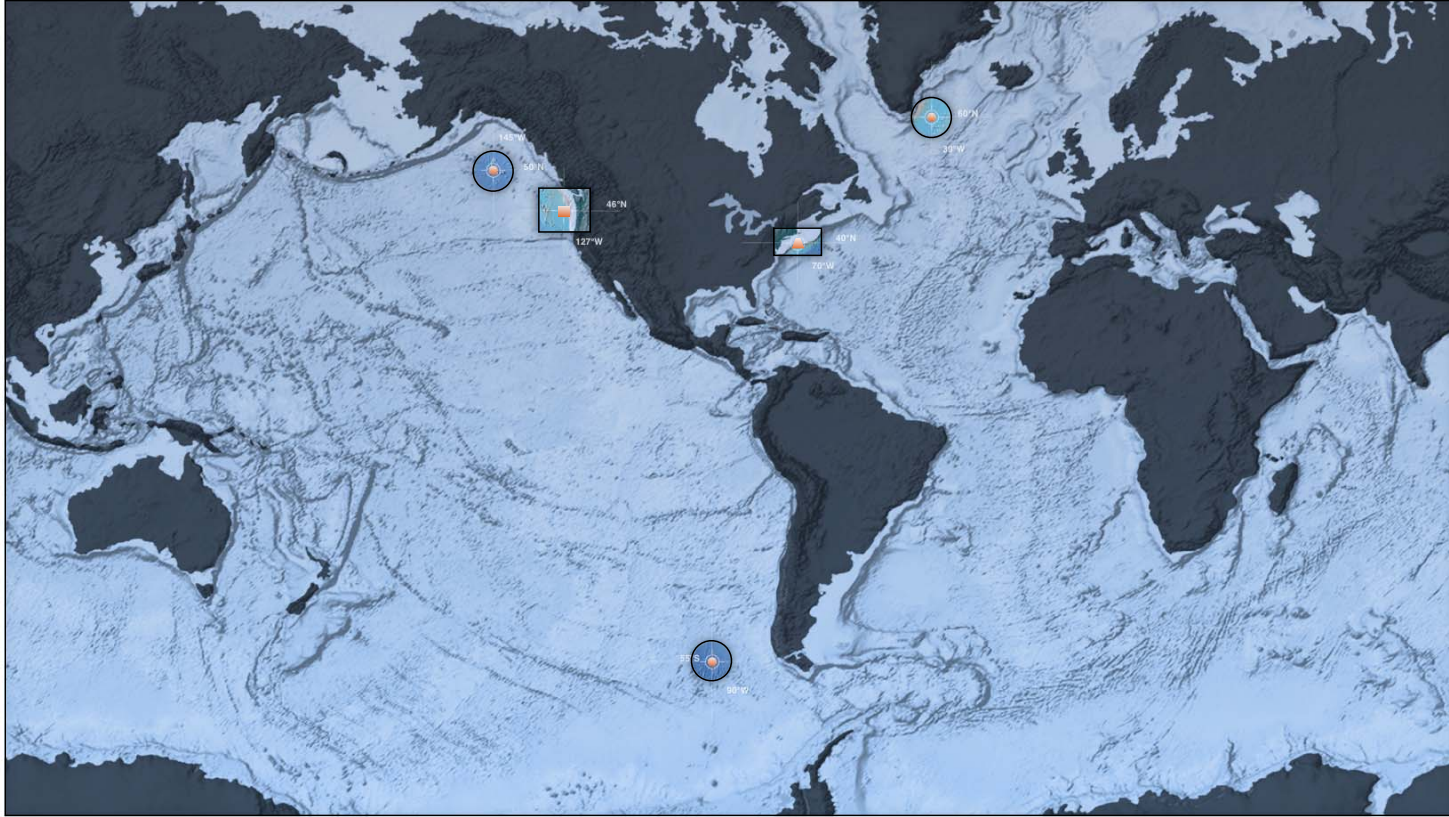
The Age of Oceanic Crust;

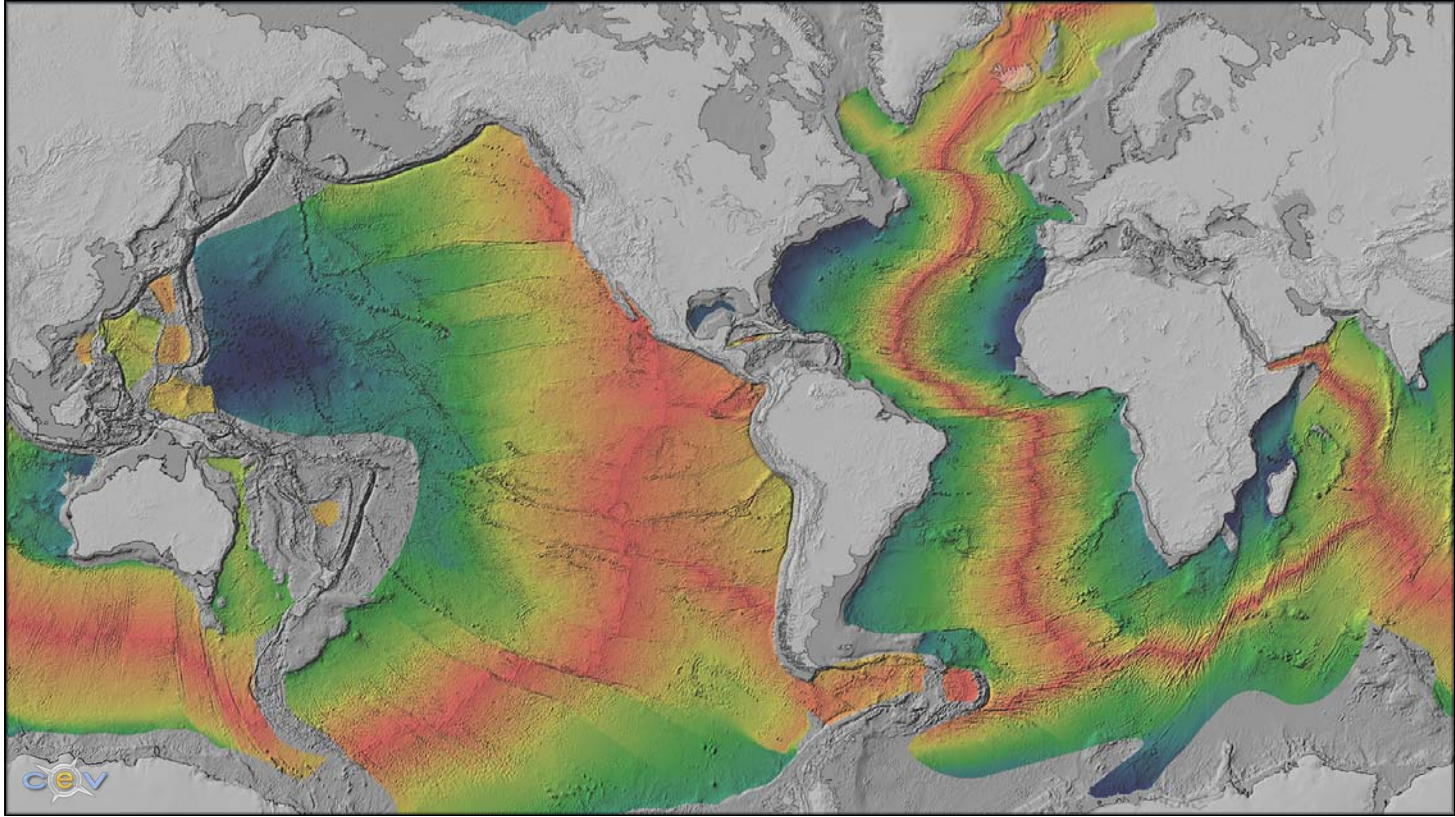
Character of Continental Margins

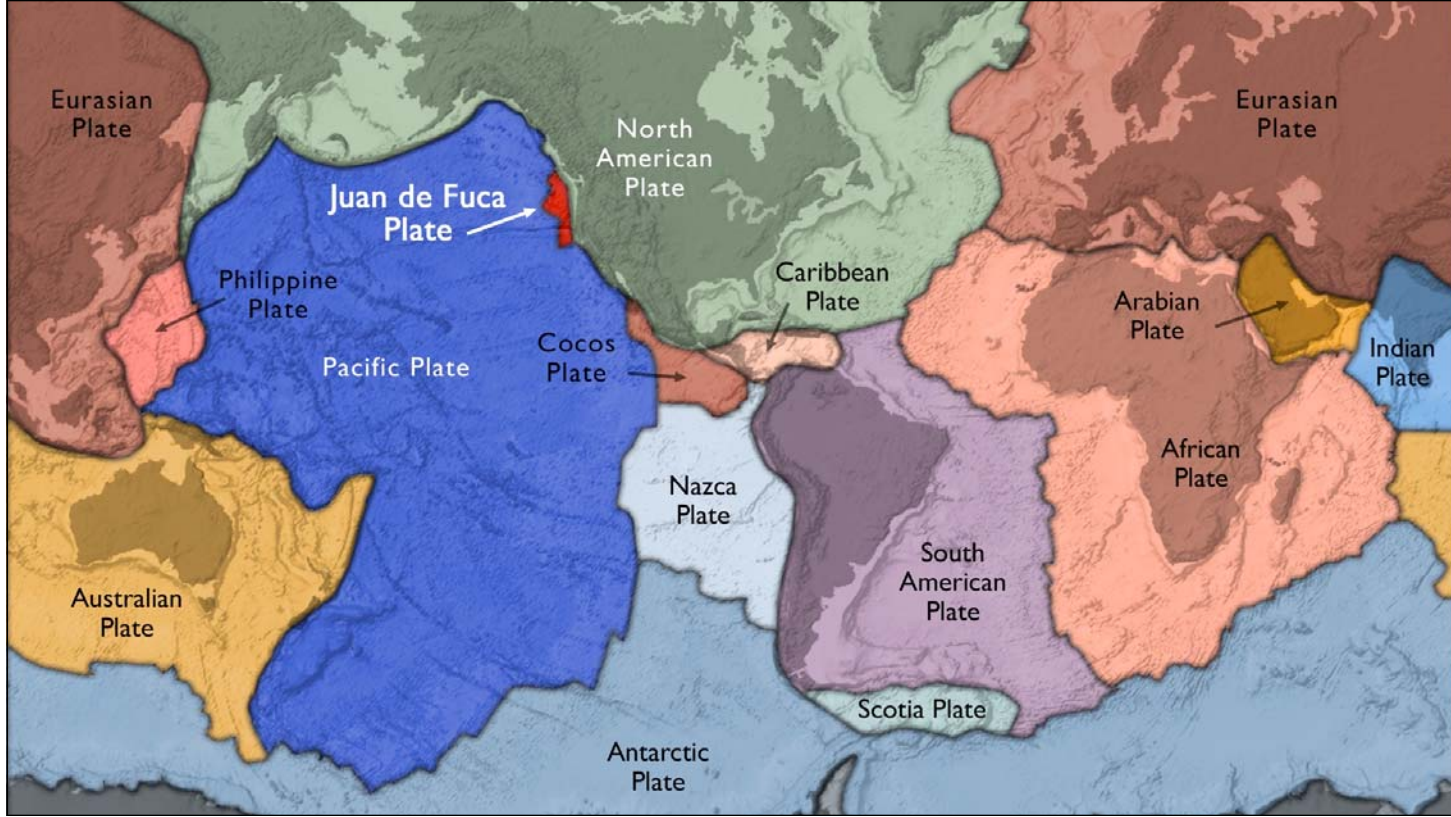
The Distribution Volcanoes, Earthquakes, Mountains;

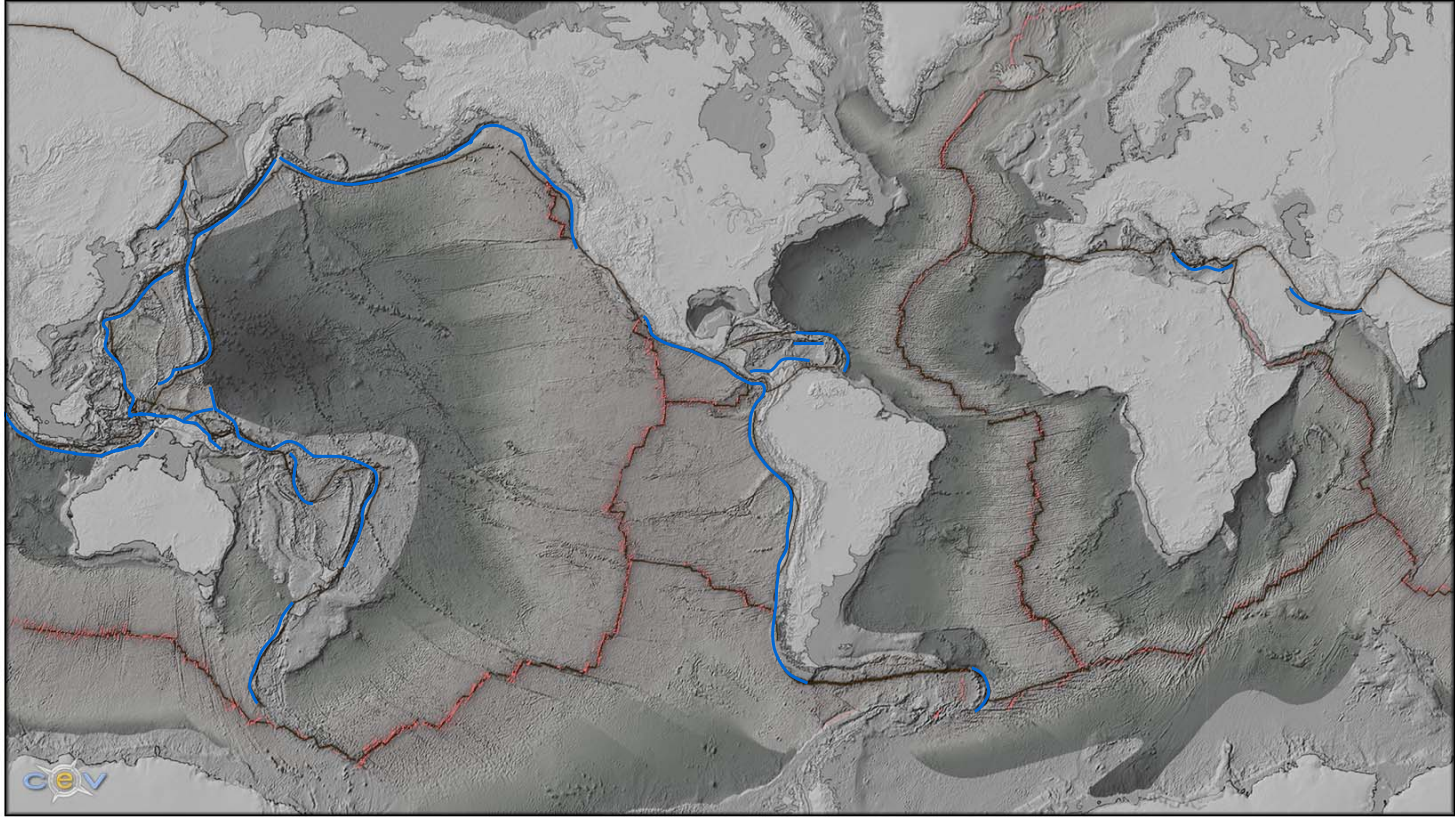
The Formation/Location of Metal/Energy Deposits;

Deep Biosphere/Possible Origin of Life.

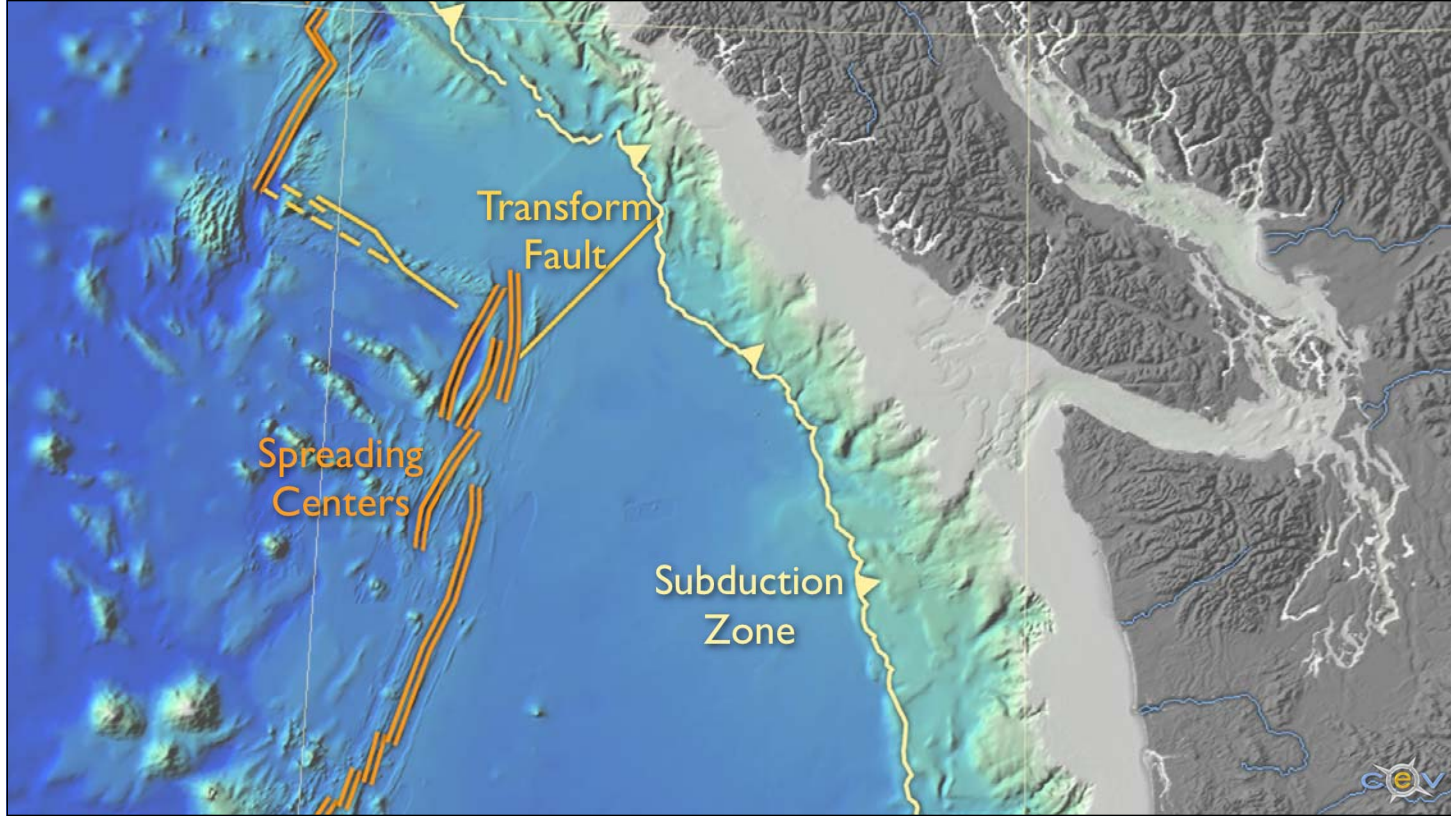


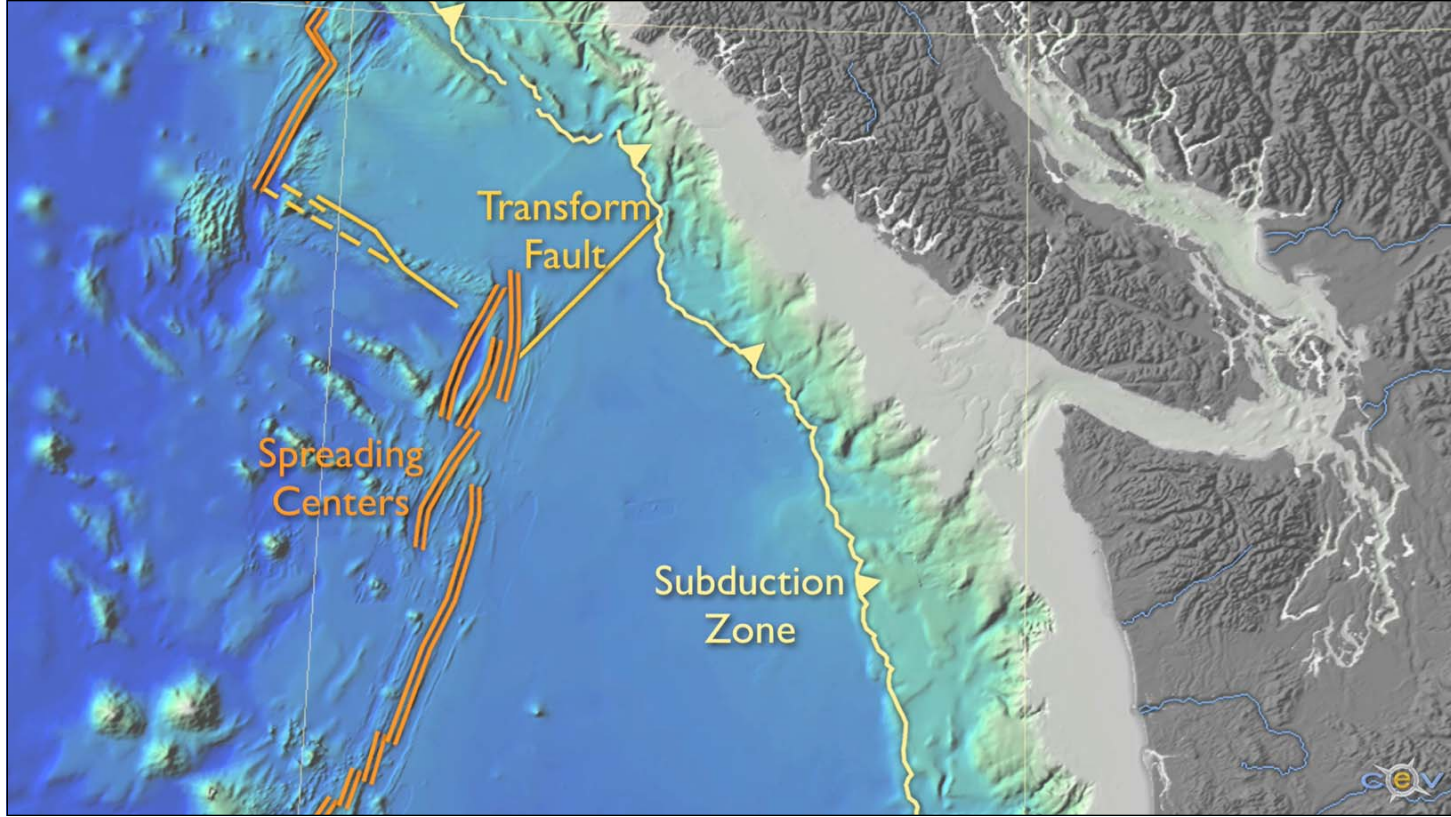


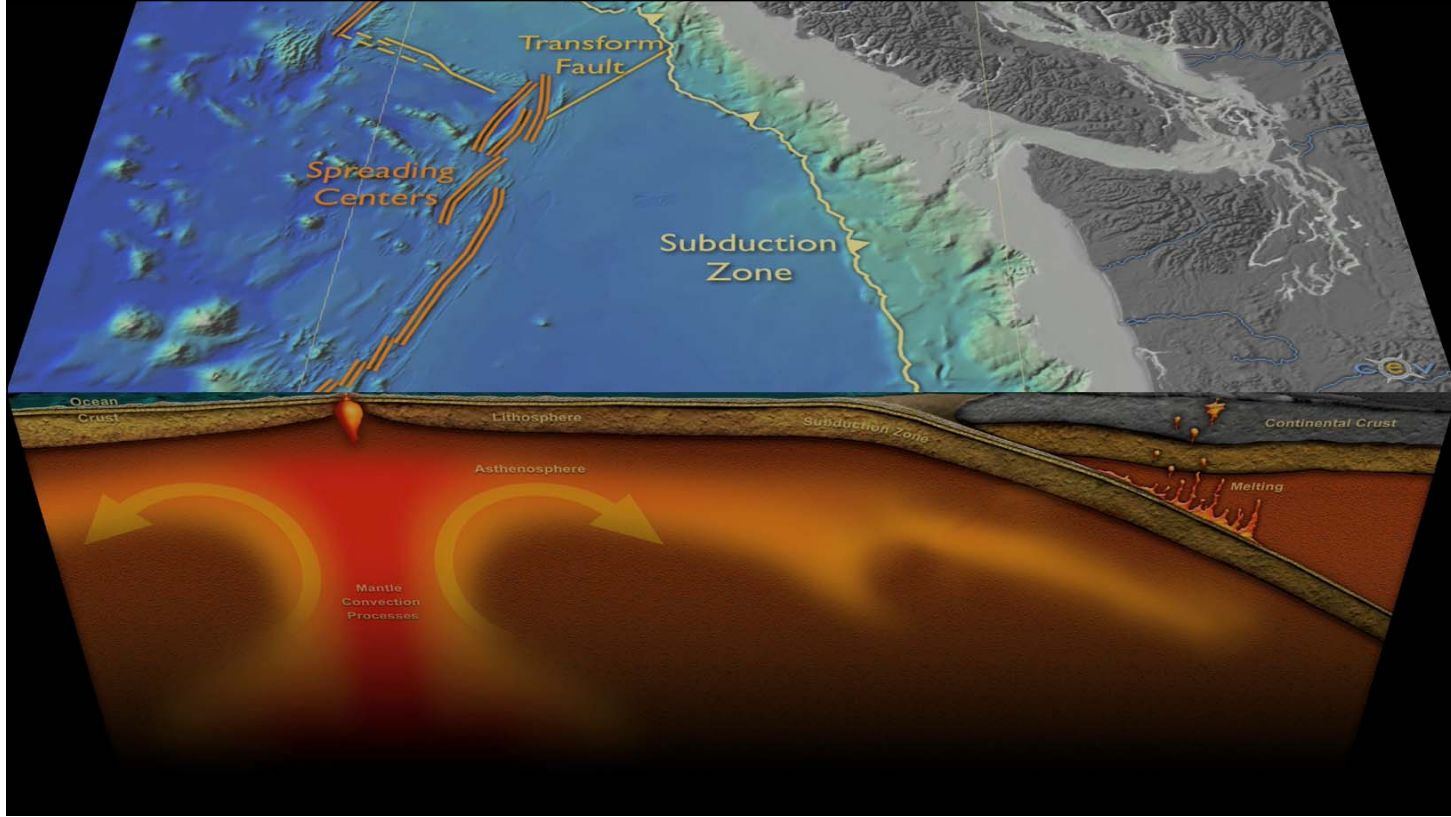


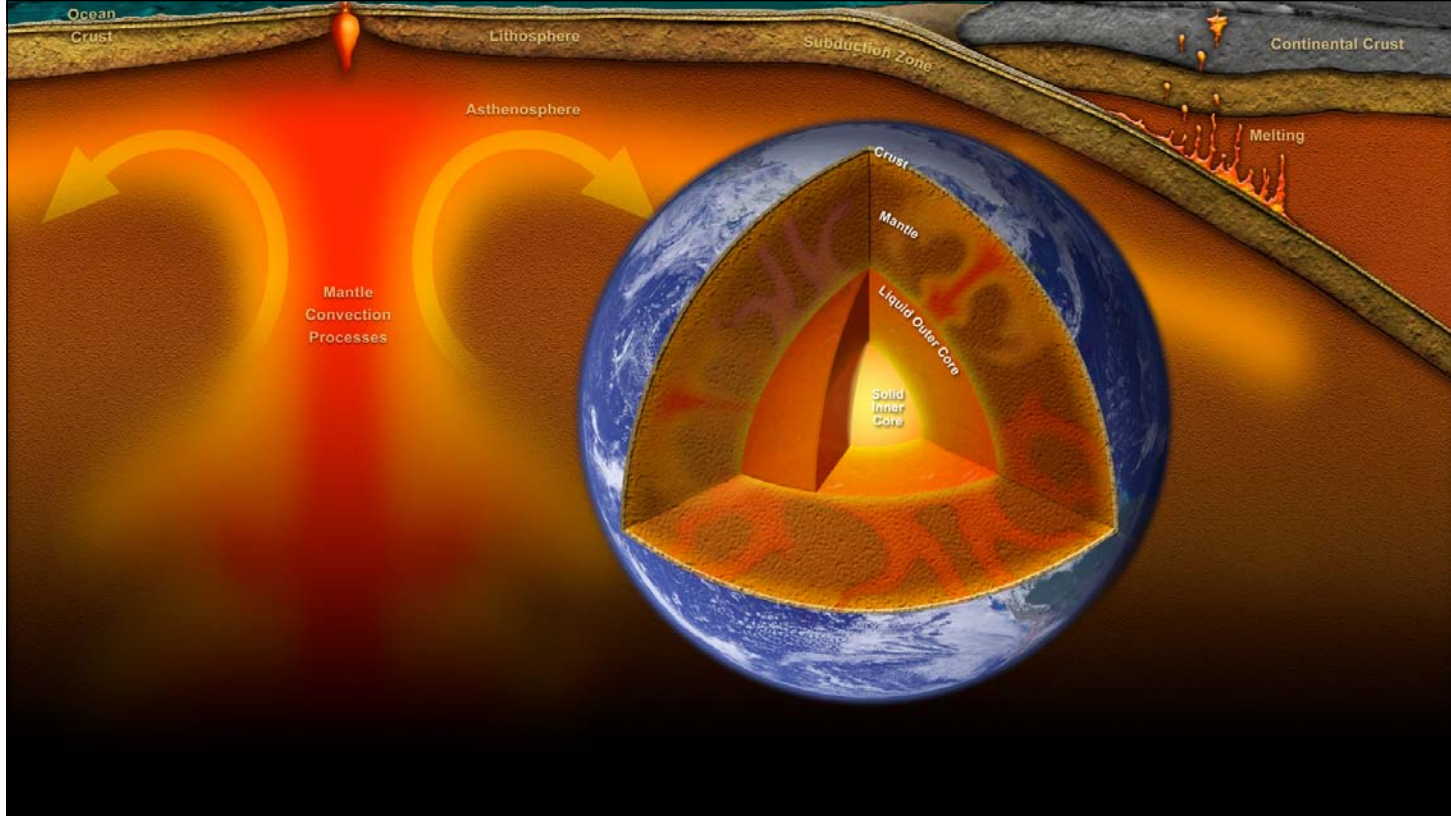


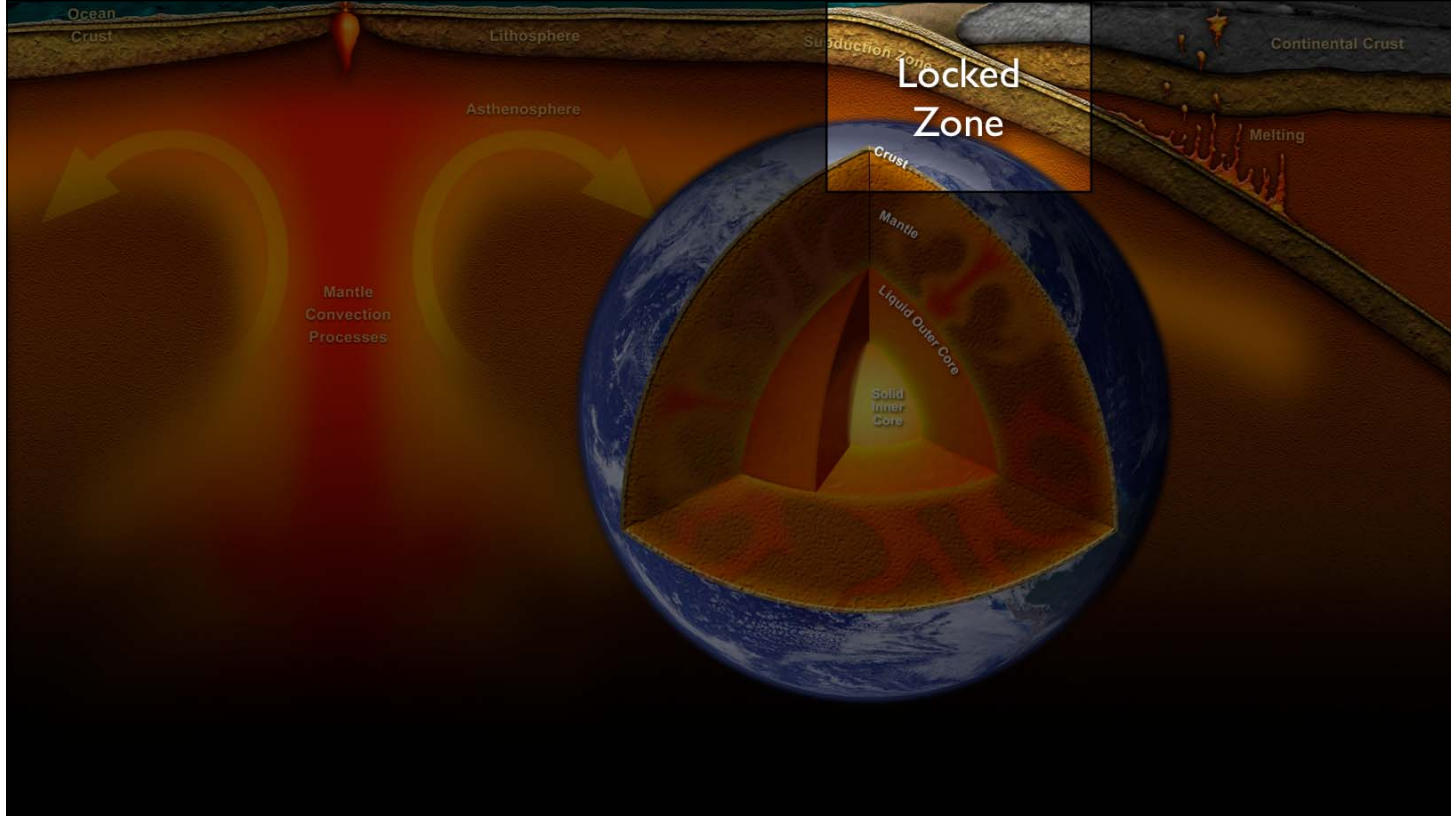


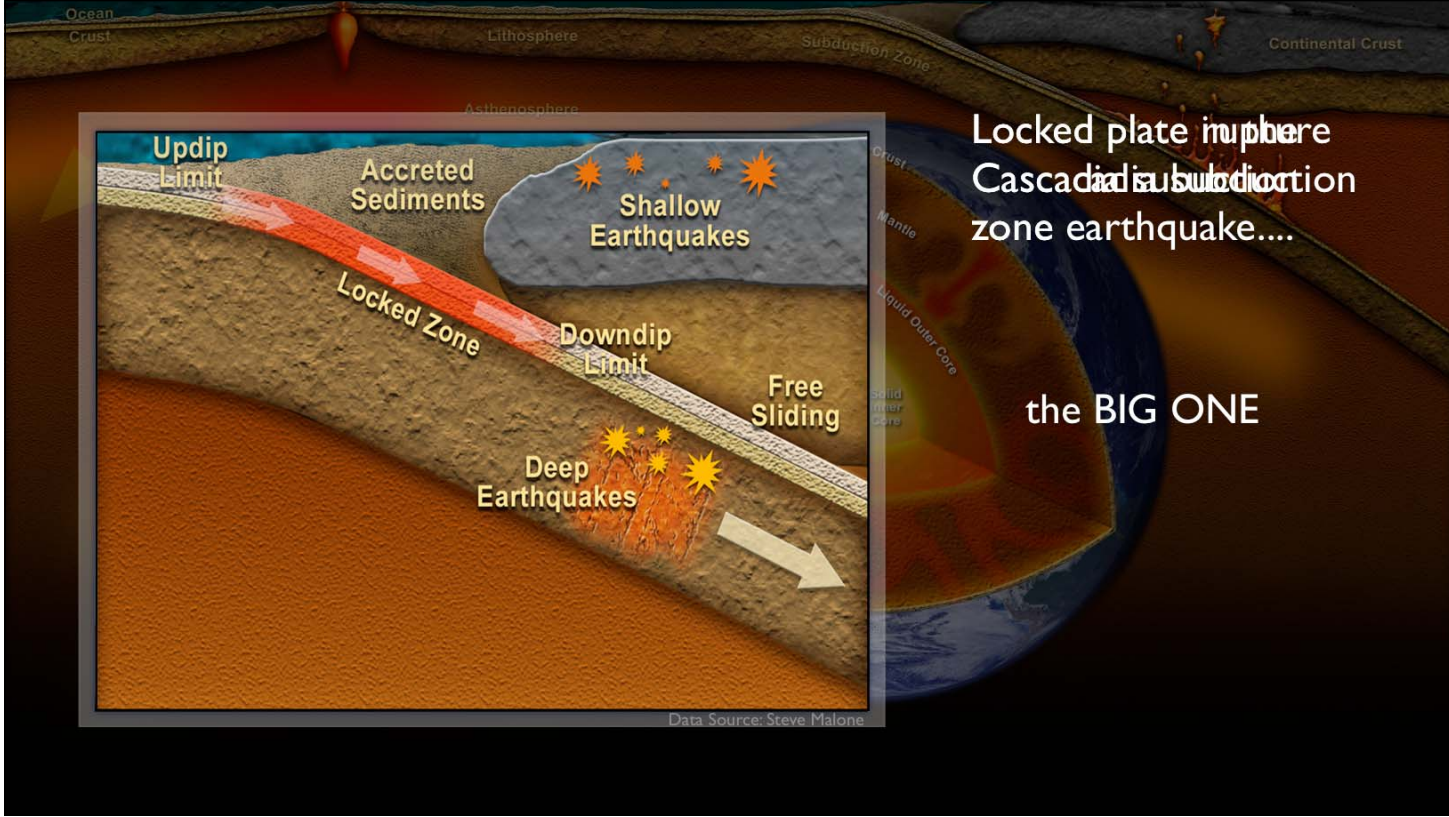








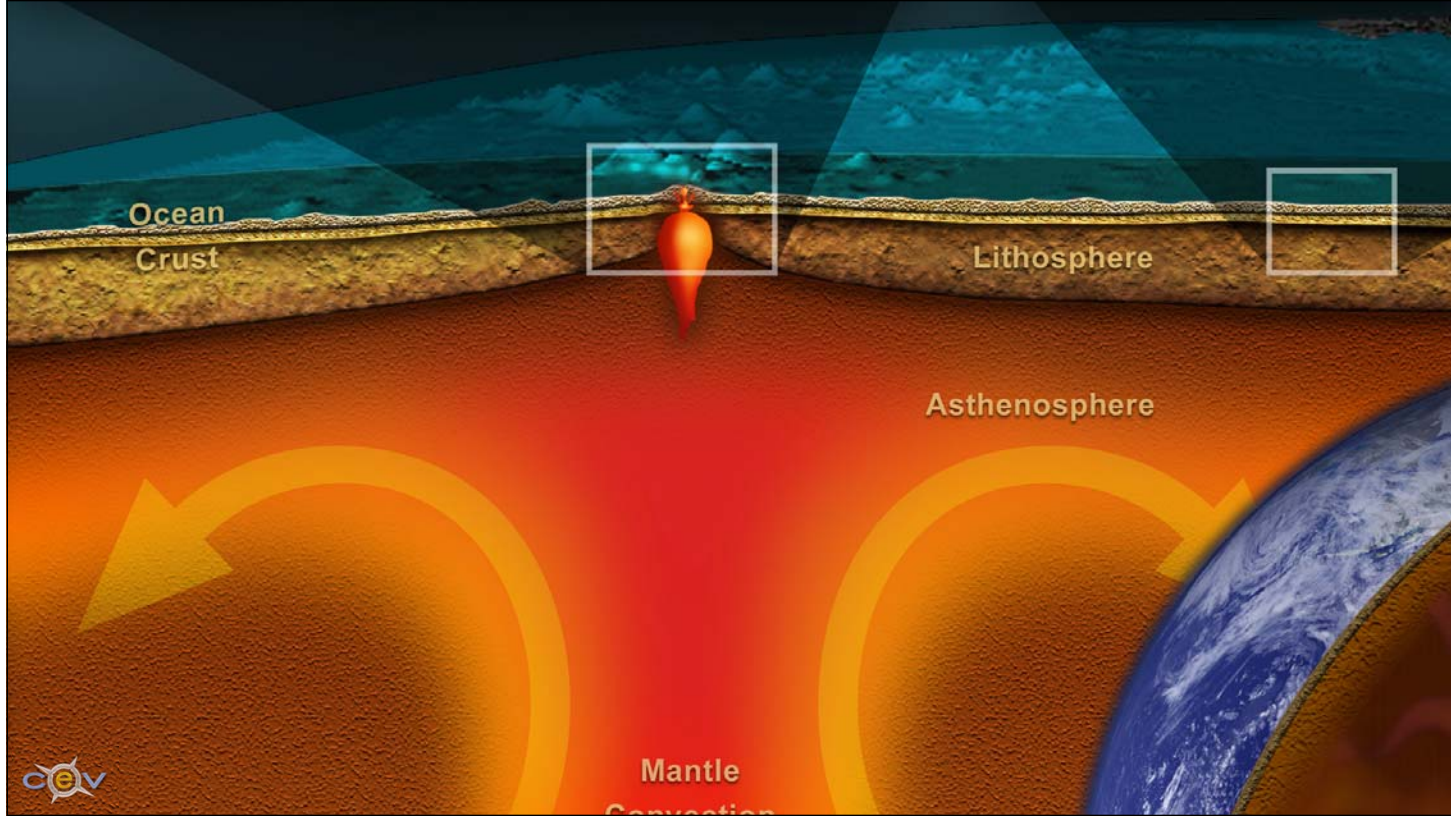




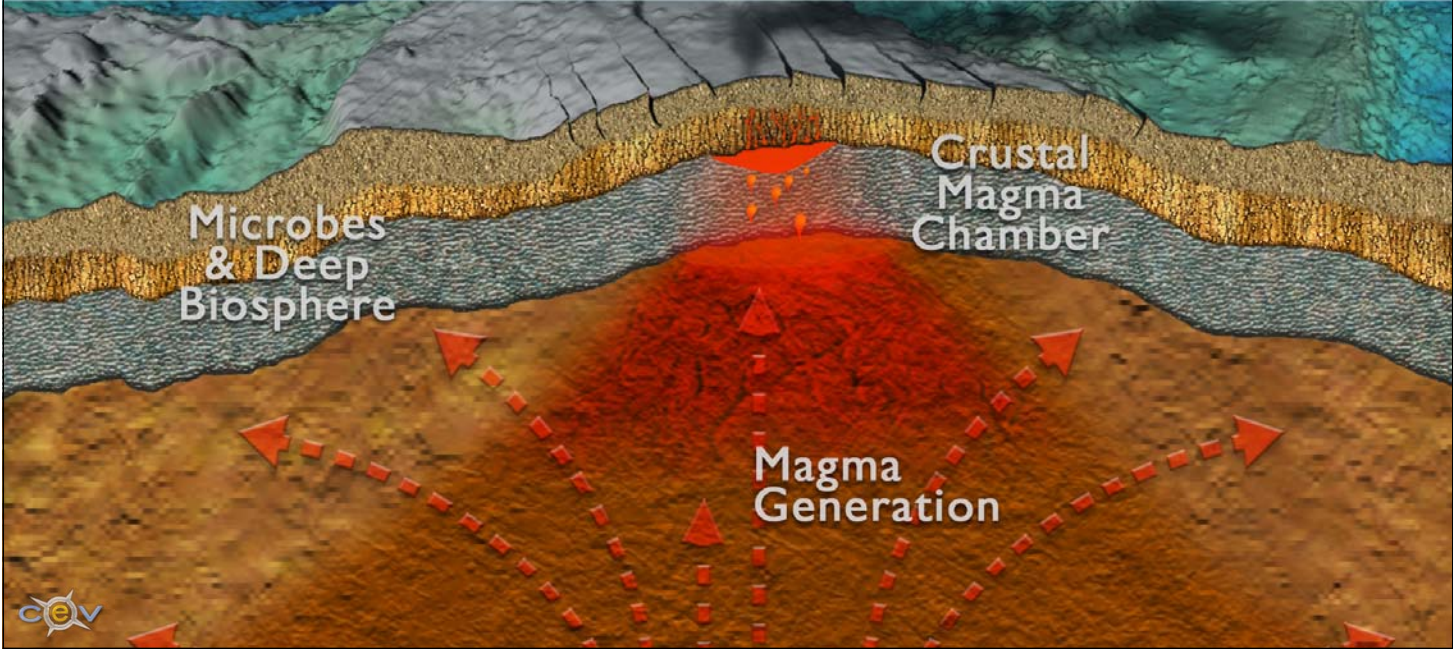
Locked plate interface
Cascadia subduction
zone earthquake....

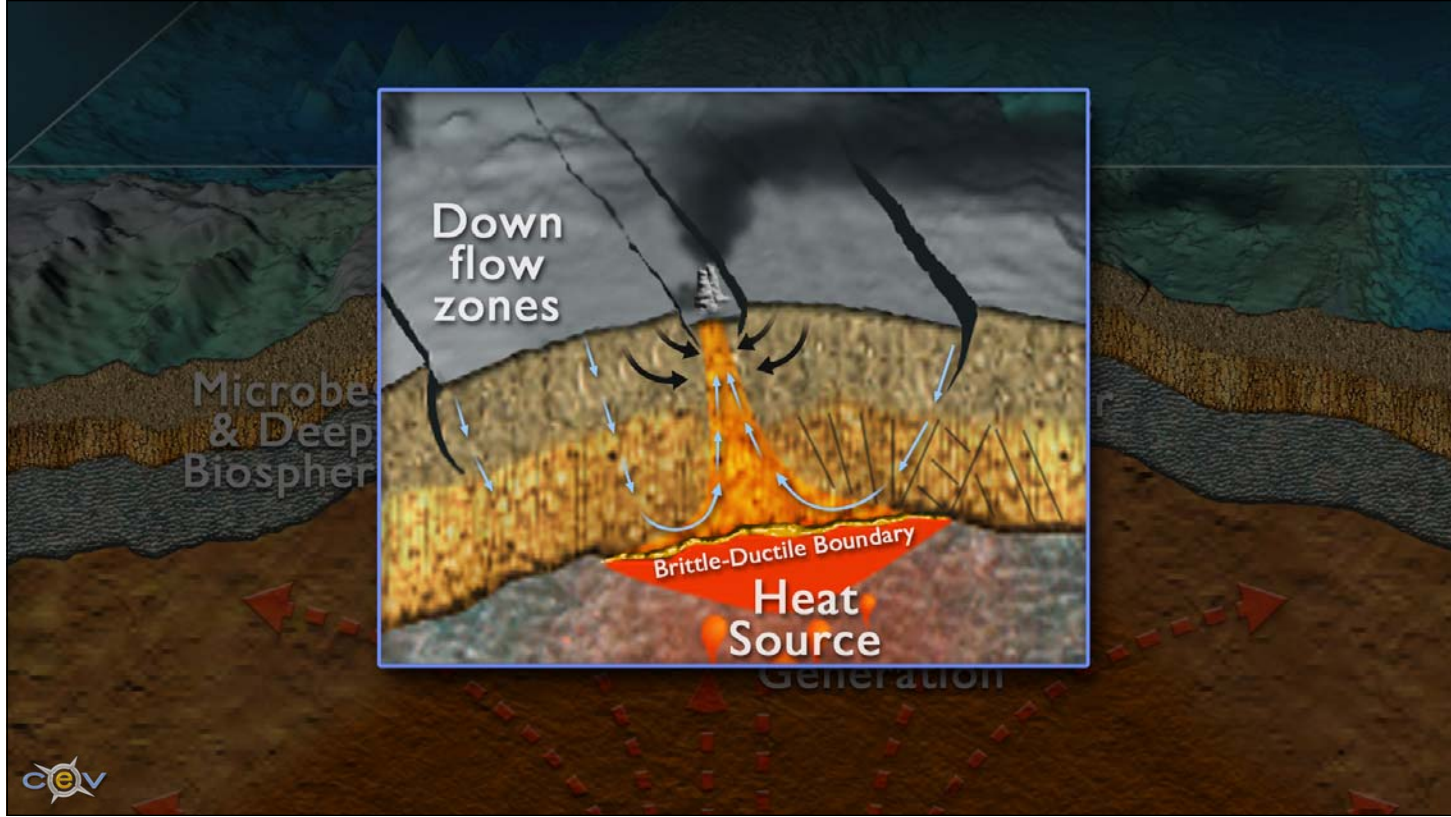
the BIG ONE

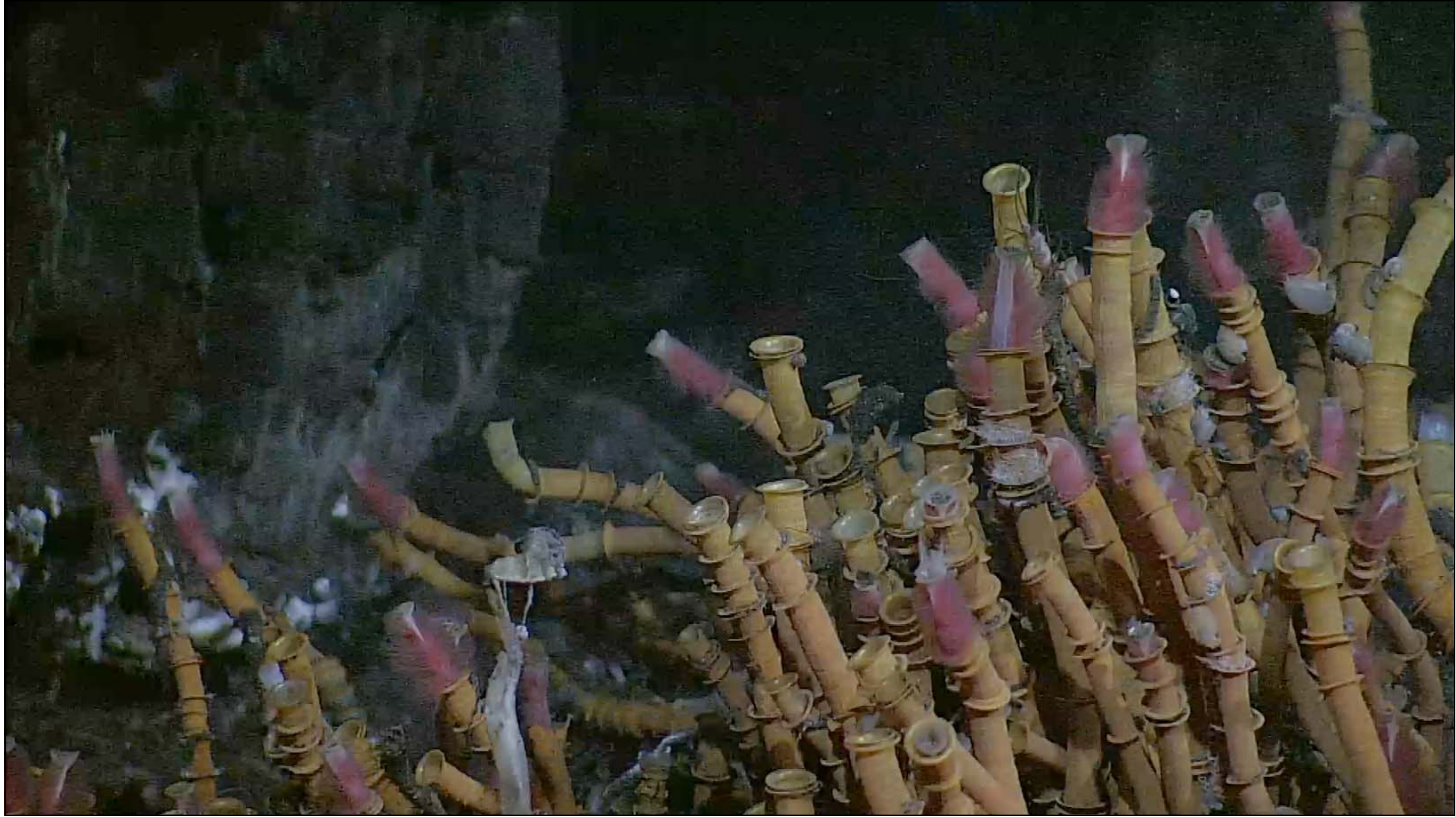
Data Source: Steve Malone



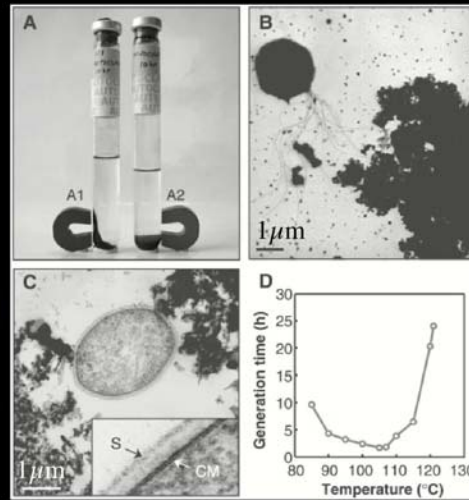
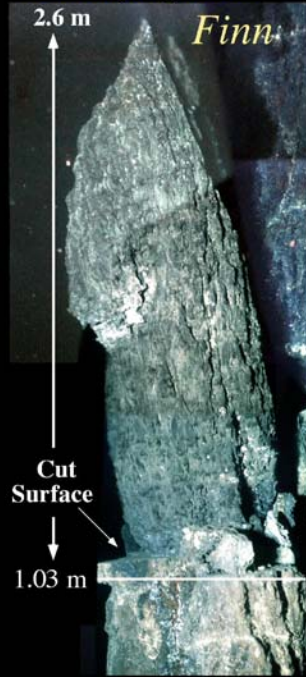
Spreading Mid-Ocean Ridges





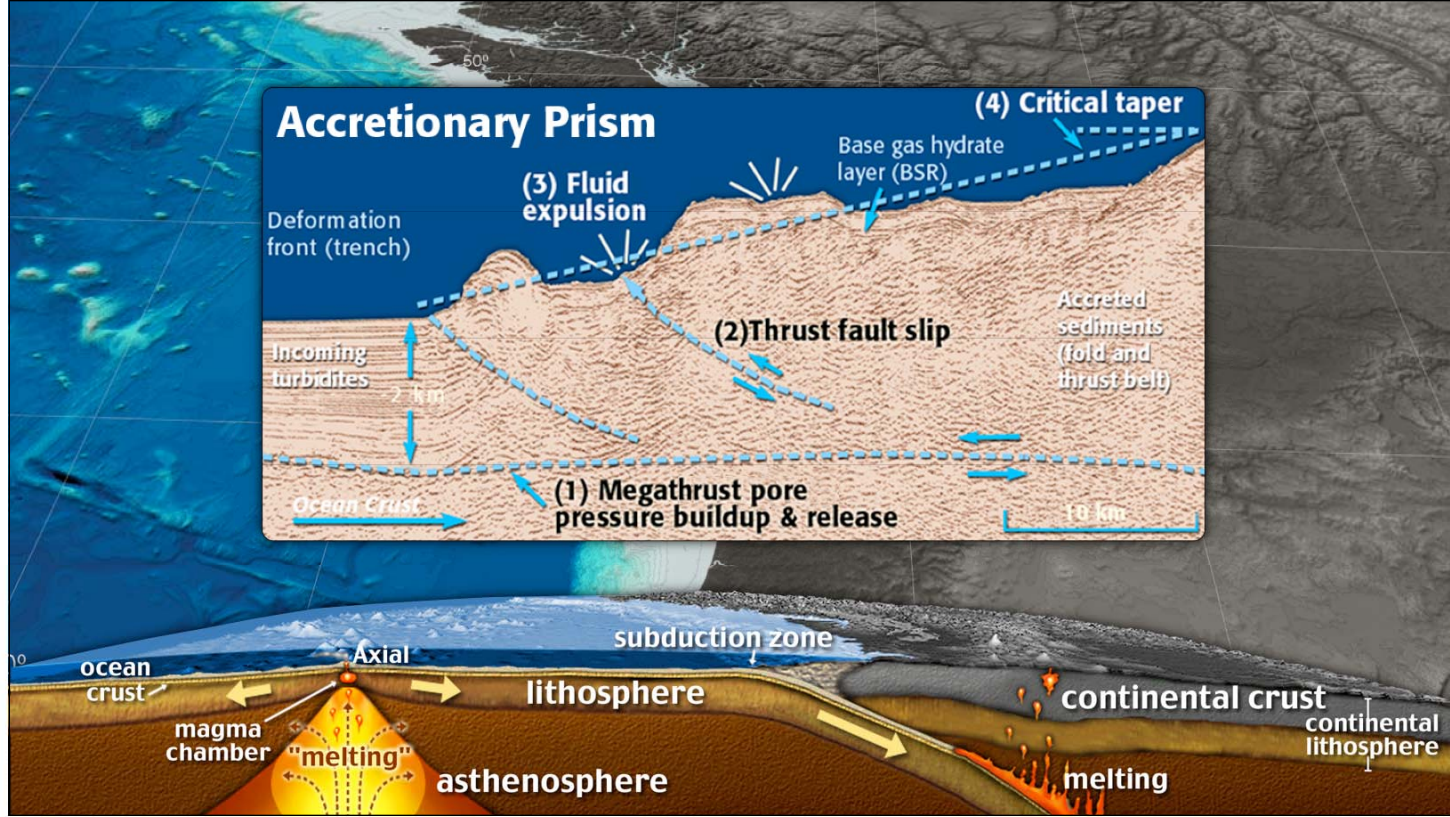


3.5 days growth

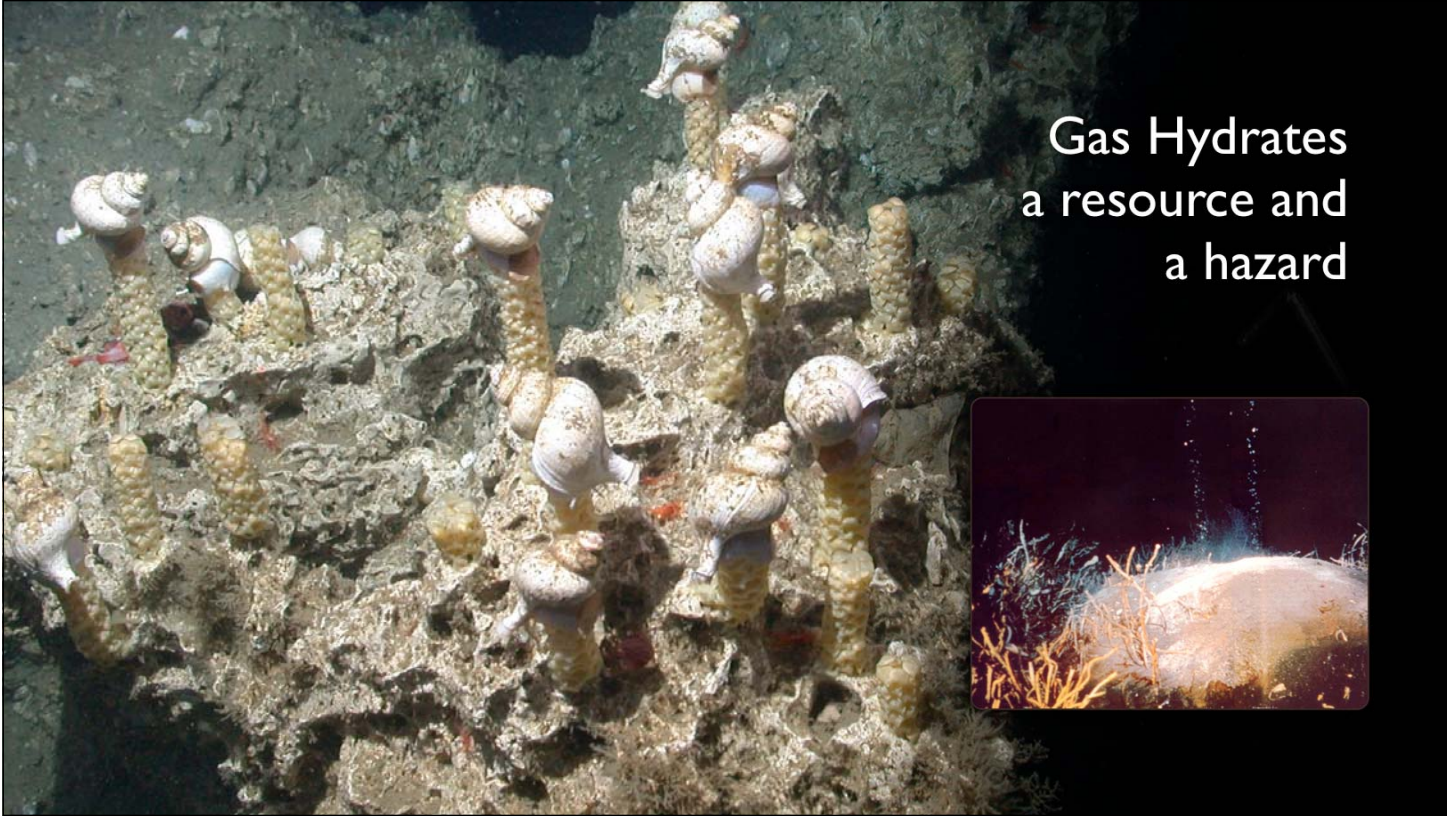


121°C organism isolated in under anaerobic conditions with and N₂-CO₂ headspace, electron donor = Fe³⁺ Formation of magnetite. Doubling time = 24 hrs.

Kashefi et al., Science 2003



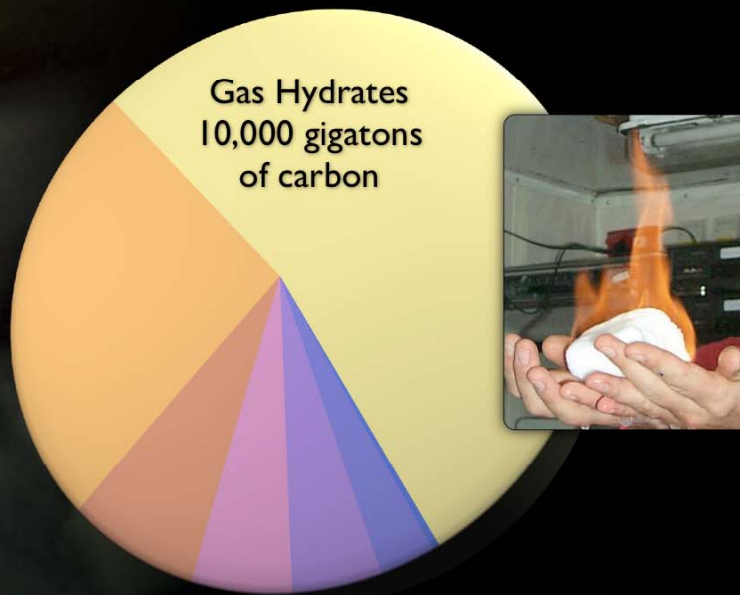
Gas Hydrates
a resource and
a hazard



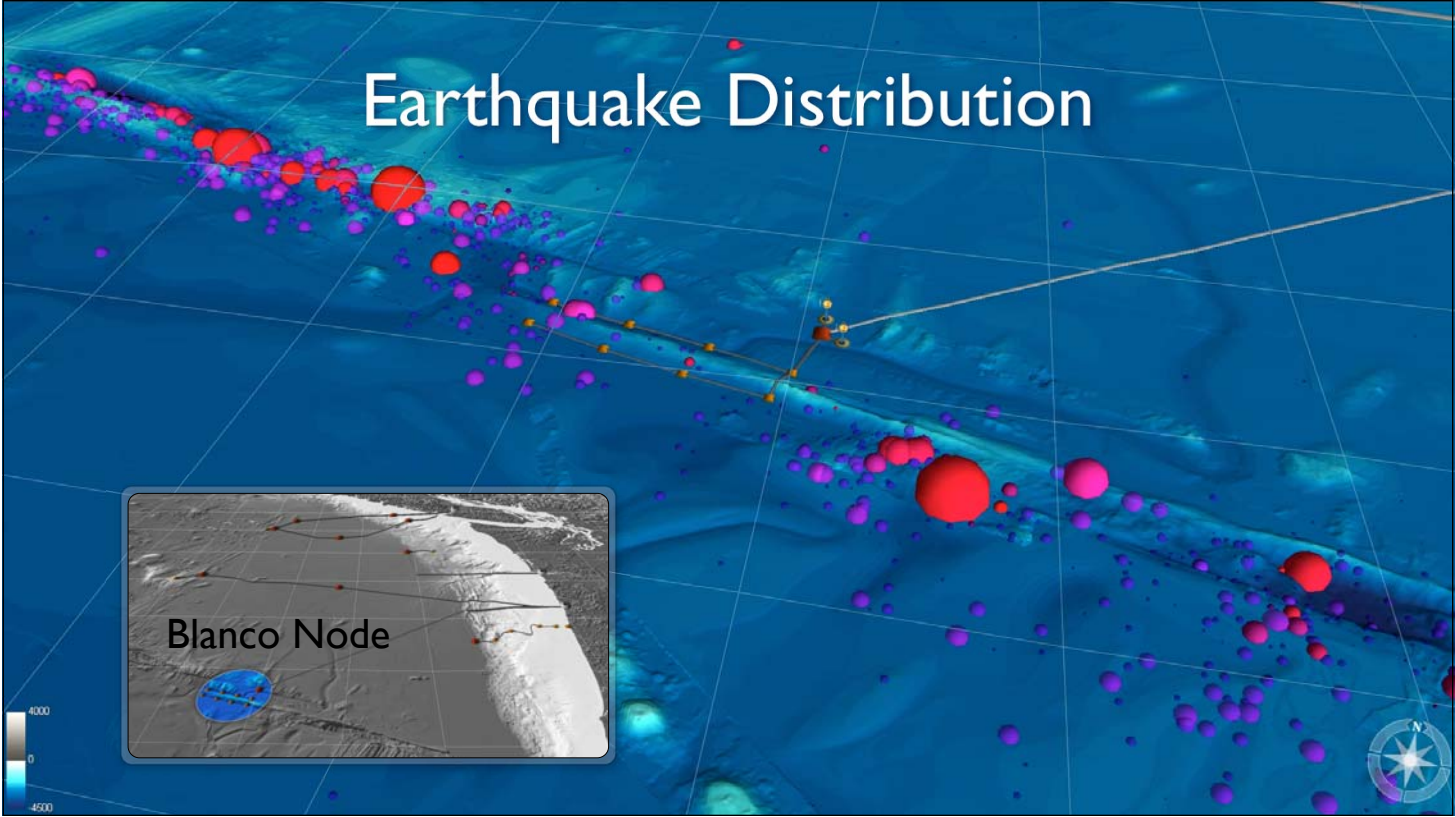
Earth's Carbon Reserves: Importance of methane hydrates

Quantities in
gigatons of carbon

atmosphere	4
detrital organic	60
peat	500
terrestrial biosphere	830
dissolved organic matter	980
soils	1400
fossil fuels	5000
gas hydrate	10,000



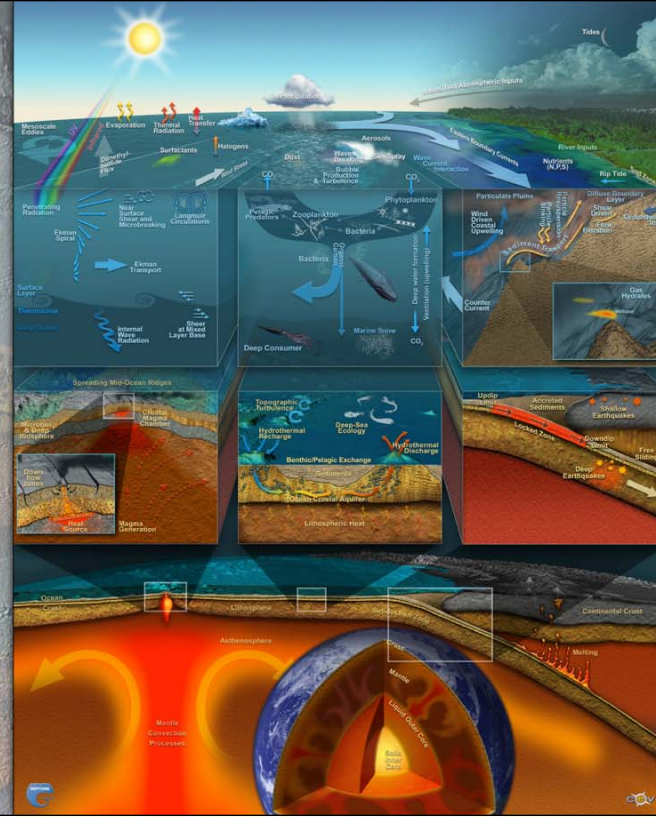
Earthquake Distribution



Blanco Node

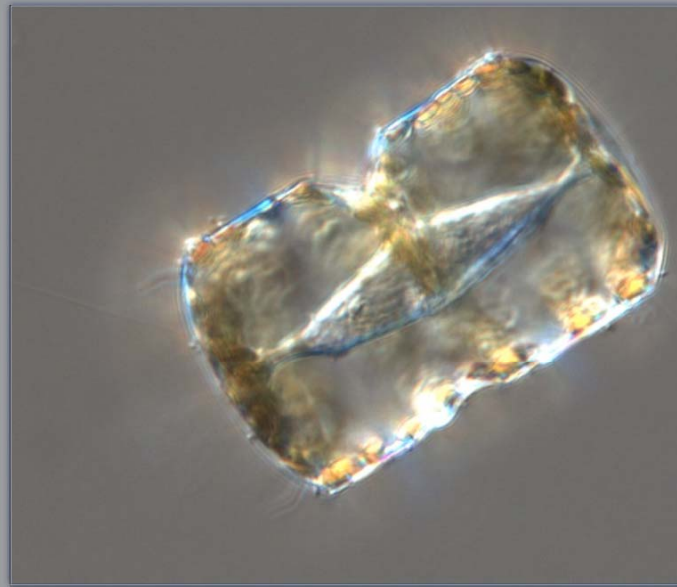
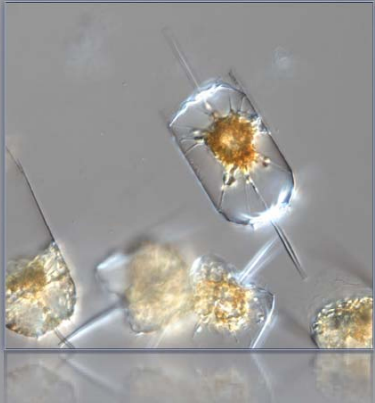
The integration of two energy sources and water, governs life on Earth.

Understanding this integration is critical to the health of our society.





Ginger Armbrust, University of Washington



Ginger Armbrust, University of Washington

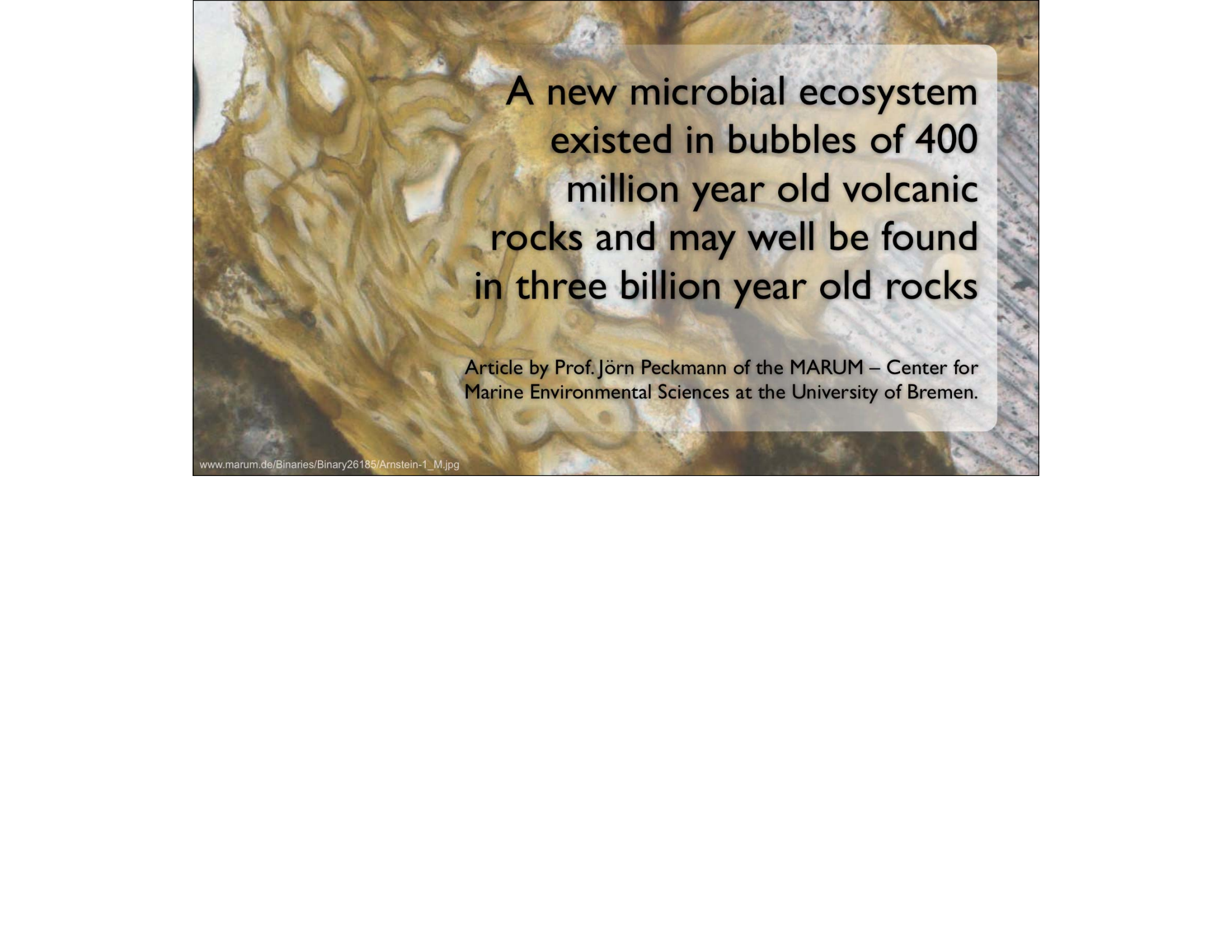


proteonomic, & metabolomic
diversity

In the last decade we have discovered that the oceans have perhaps Earth's largest genetic, proteomic, and metabolomic diversity.



The dynamics in the microbial fauna remains completely unexplored even though evidence suggest marine microbial fauna have rapid genetic evolution rates.

A microscopic image showing intricate, golden-brown, fibrous structures that resemble microbial mats or filaments. These structures are set against a lighter, more crystalline background, likely representing ancient volcanic rocks. The overall appearance is complex and organic, suggesting a rich microbial ecosystem.

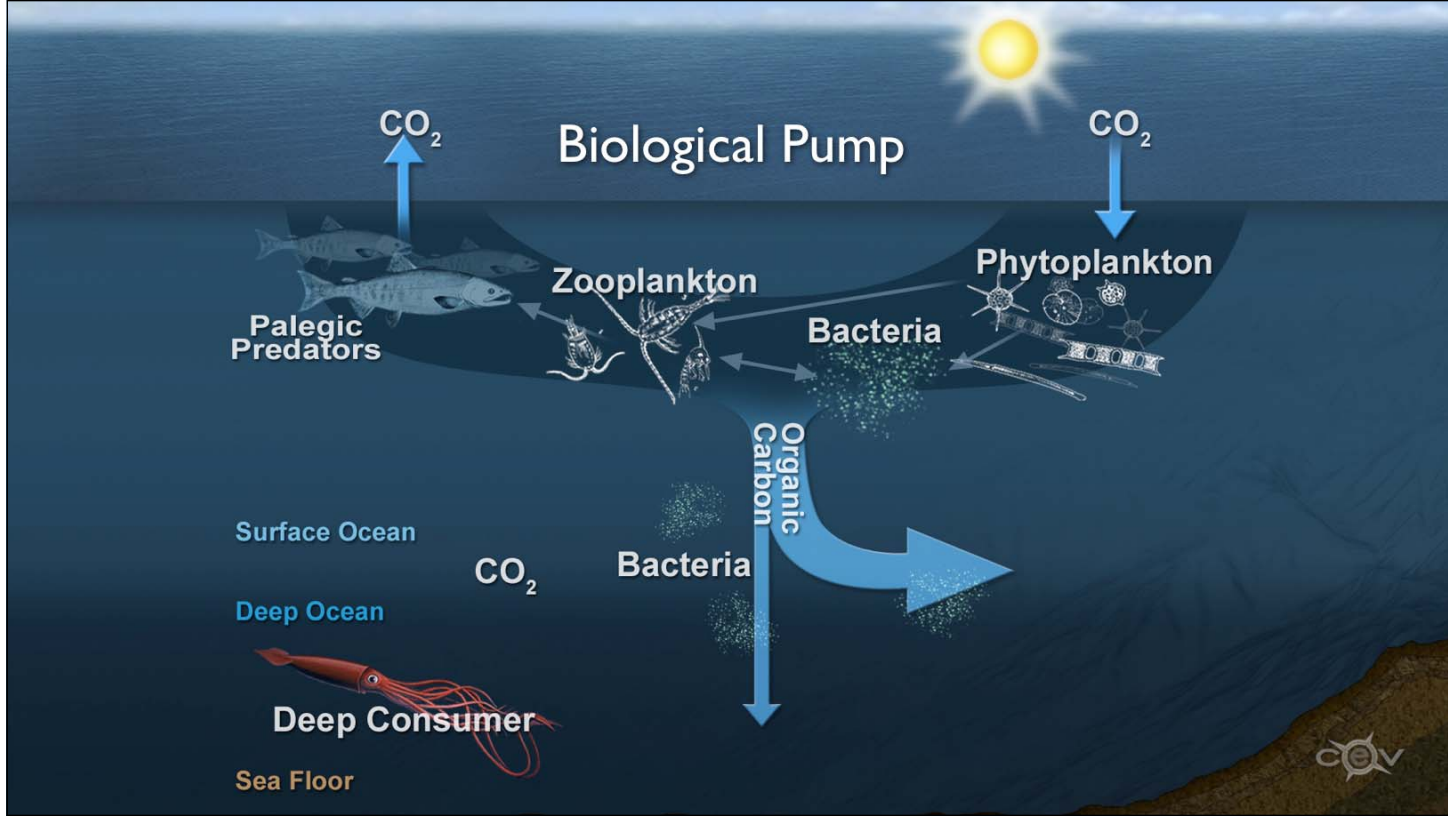
**A new microbial ecosystem
existed in bubbles of 400
million year old volcanic
rocks and may well be found
in three billion year old rocks**

Article by Prof. Jörn Peckmann of the MARUM – Center for
Marine Environmental Sciences at the University of Bremen.

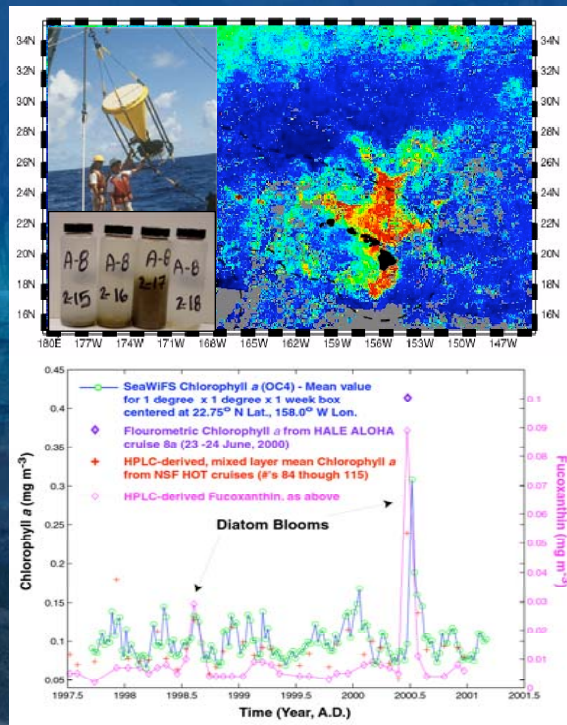




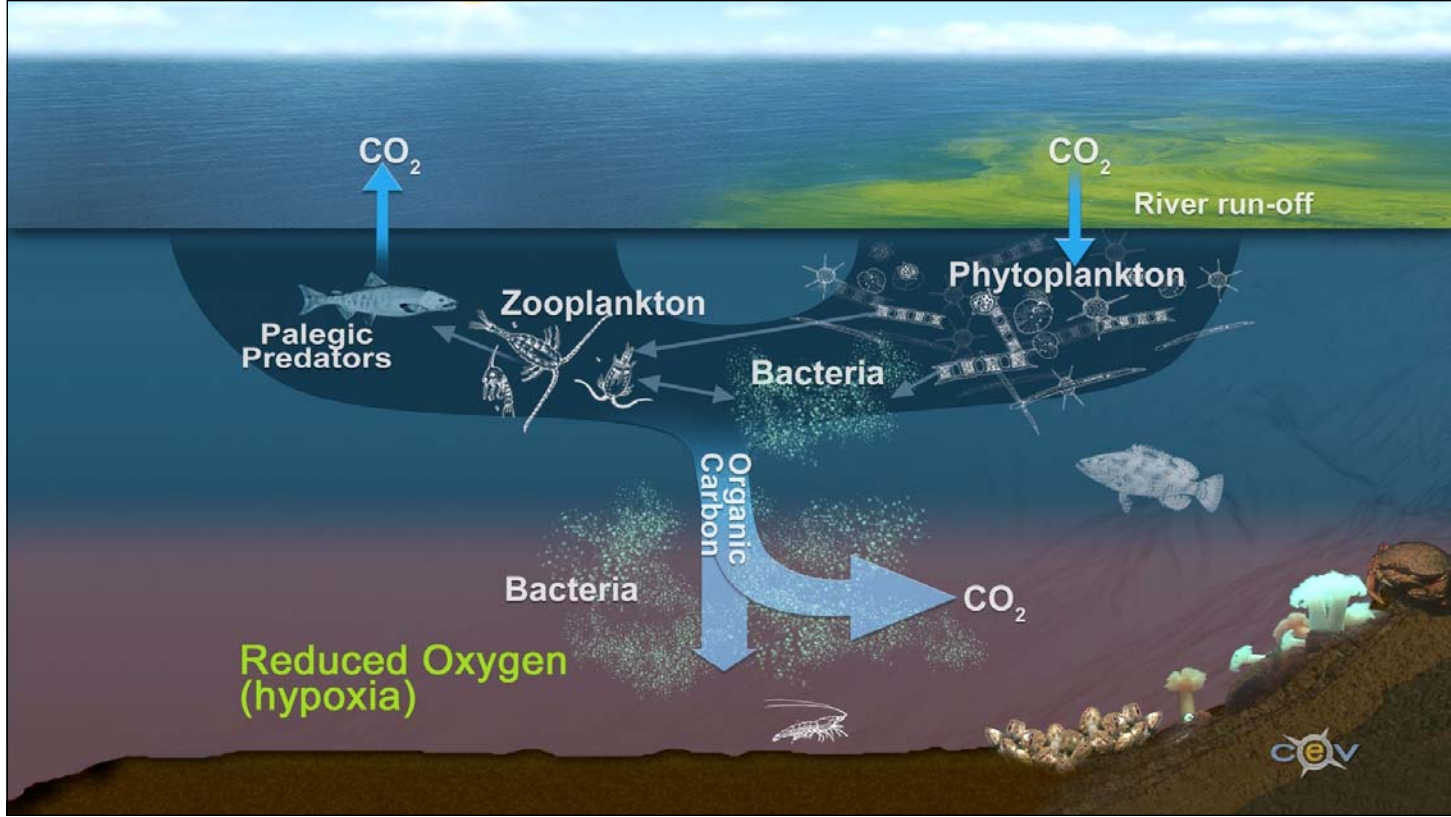
Photo and Sound from: Kate Stanford, University of Washington



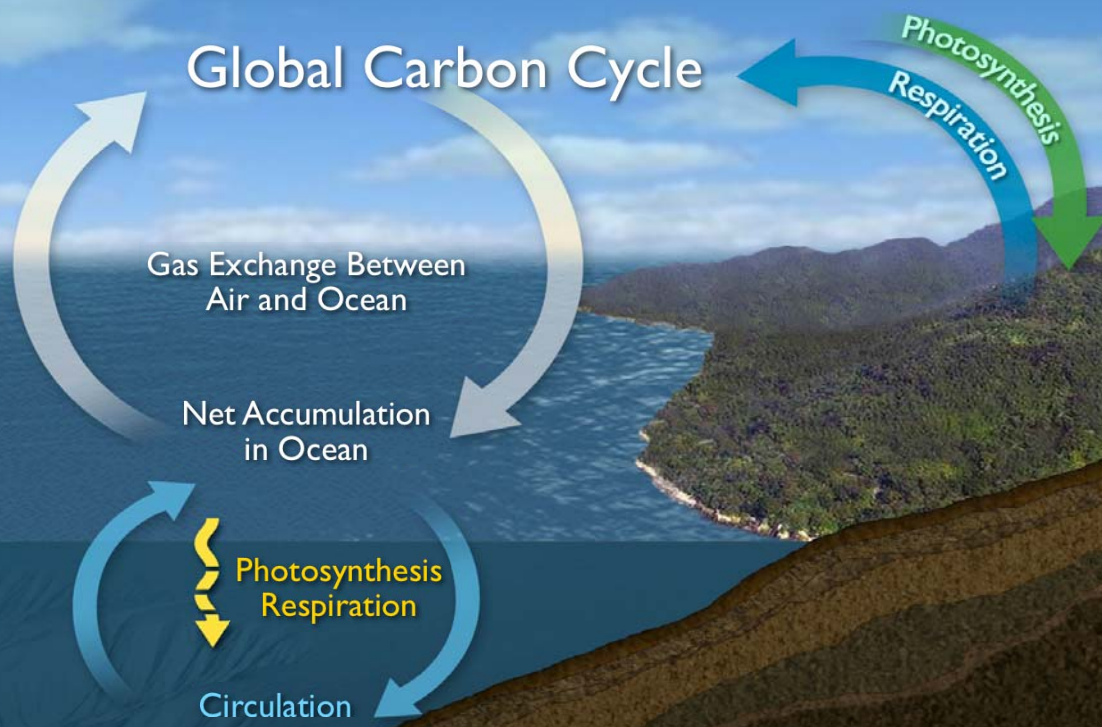
Emphasize what happens to atmospheric ppm without bio pump. Up to 680 ppm!



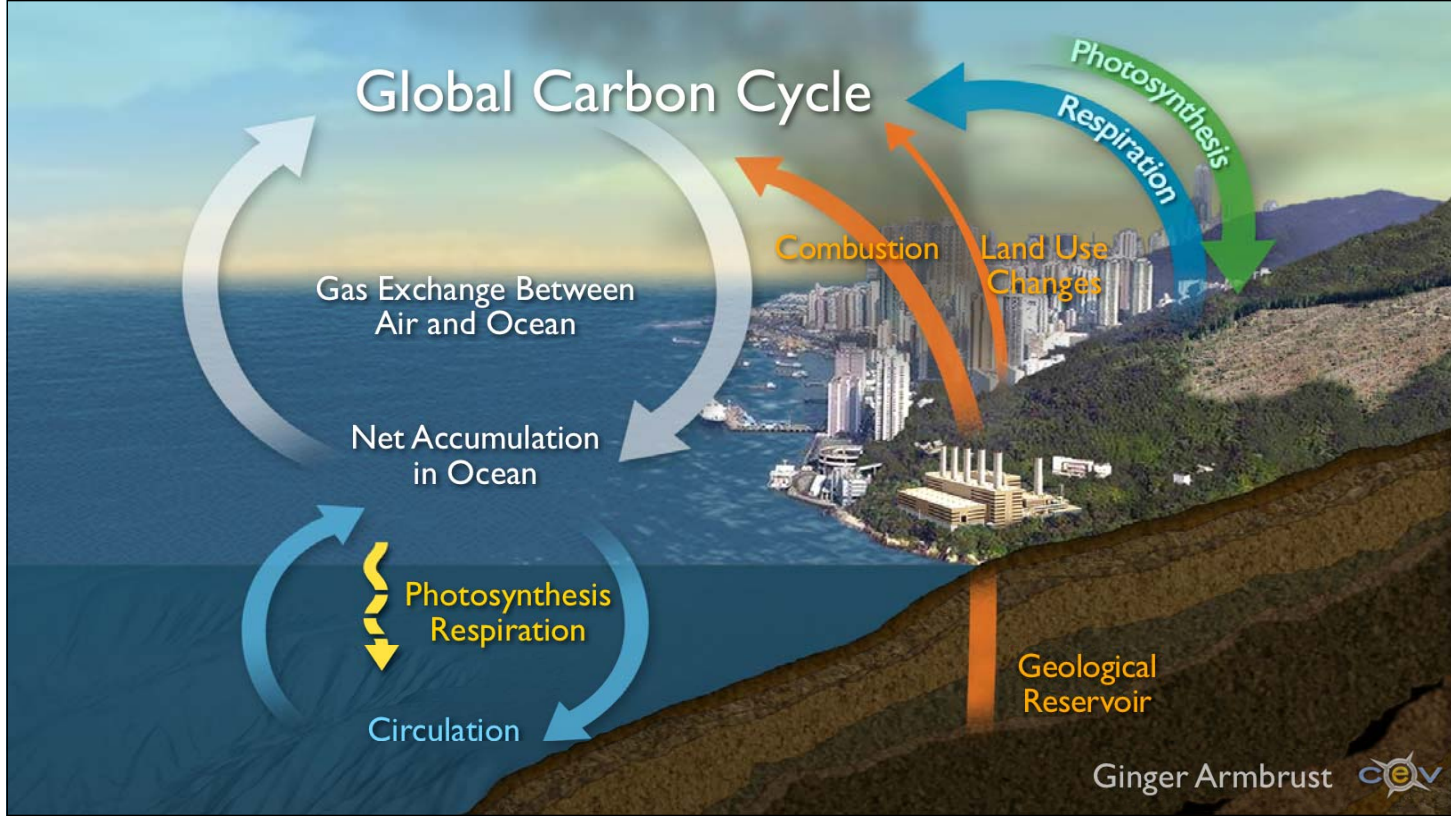
Episodic blooms play a large role in sequestering organic carbon to the lithosphere. Understanding these events is central to proposals for fertilizing the oceans for carbon sequestration.



Global Carbon Cycle



Global Carbon Cycle



The ocean's large capacities to store and transport

