What is the best way to observe the ocean?

What are the independent variables of the ocean state?

How was the ocean observed so far…

What processes to observe

What technologies are available

Who is driving who?

How does our understanding of the ocean change our future observation strategies?

Oceanography is an observationally driven field!

What are the independent variables for the ocean?

What do they measure and what is their use?

Geological: coastlines, bathymetry, sediment thickness

Physics: Temperature, horizontal velocity, vertical velocity, Sea-surface height

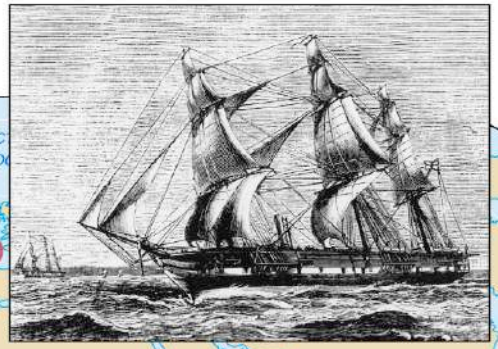
Biology: Chl-a, Productivity, Zooplankton, Phytoplankton, Fish and Egg counts, etc

Chemistry: Salinity, Carbon, Nitrogen, Iron, Oxygen…

How was the ocean observed so far?

Lots of historical account of early explorations – (see book).

HMS *Challenger*



HMS *Challenger - some facts*

Crew: 243
Scientists: 6
Duration of Expedition: 4 years
Distance sailed: 127,000 km (68,890 miles)
Number of sampling stations: 362
Number of depth soundings made: 492
Number of dredges taken: 133
Number of new species of animals and plants discovered: 4,700

1895, almost a quarter of a century after the ship set sail.

The fifty thick tomes of the report, containing 29552 pages, were written by an international galaxy of scientists and many of these reports still form a starting point for specialist studies in oceanography.

4000 new species of animals taken by the trawls and dredges were documented and are still referred to by scientists from all over the world.

The reports were the tangible evidence of the achievements of the Challenger venture, but perhaps of much greater importance in the long term was the co-operation between scientists of many countries, inspired by Wyville Thomson's leadership, which set the young science of oceanography on the path to becoming the truly international discipline that it is today.

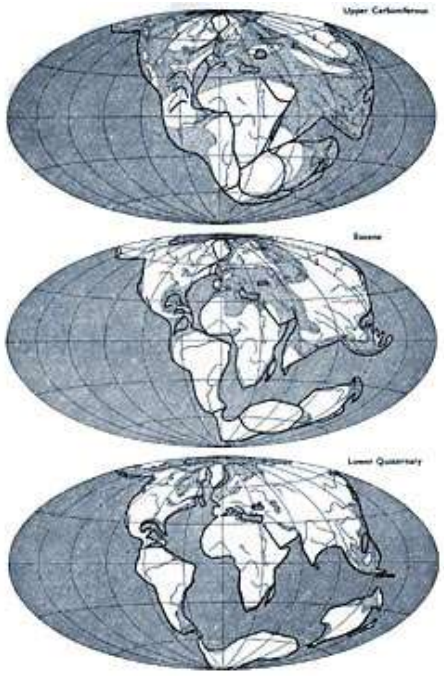
Other key milestones in Oceanography

1770's: Ben Franklin refers to Gulf Stream as "river in the ocean"

1830's: Darwin's HMS Beagle expedition

1847: Maury & Prince Albert of Monaco generate first maps of ocean winds and currents

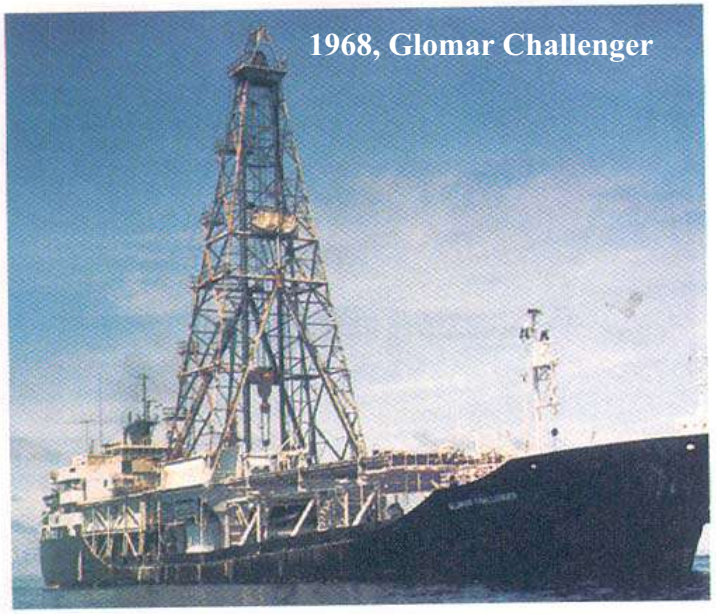
early 1900's: advent of submarine brings new technologies (echo sonar, magnetometer) → Navy $!



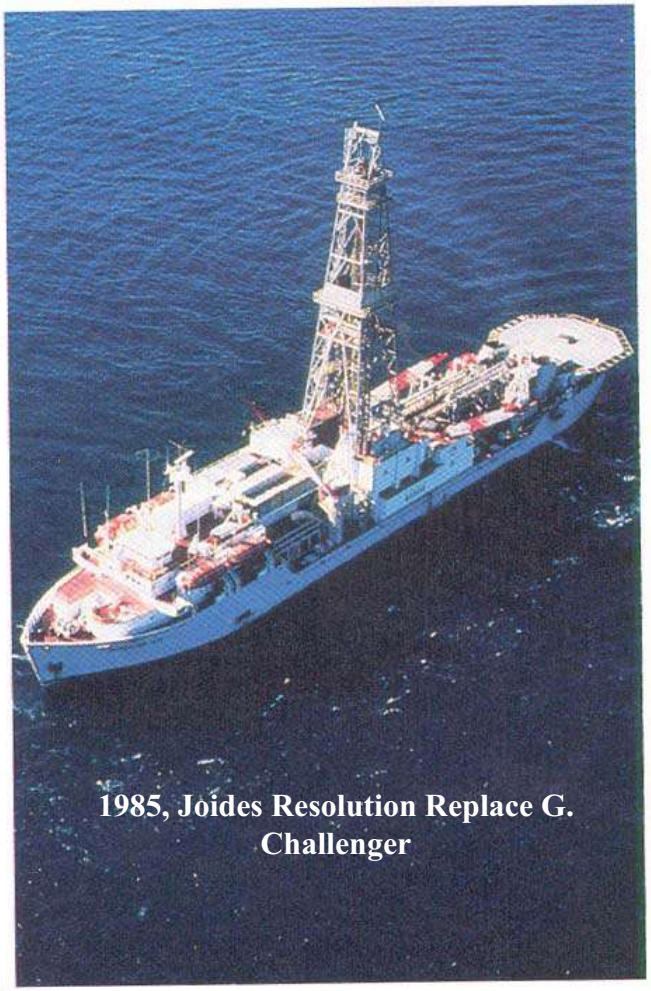
1920's: Alfred Wegener proposes "continental drift"
1950-60's: Heezen, Tharp, Menard discover mid-ocean ridges
1950's: seafloor spreading proposed by Hess & Dietz
1965: Wilson proposes unified theory of plate tectonics

International Observational Programs

Deep Sea Drilling Project - DSDP



(a)



(b)

Figure 1-18

(a) The *Glomar Challenger* could produce 8800 continuous or 10,000 intermittent hp for propulsion and for operating drilling equipment. To remain over the drill site, the ship used dynamic positioning that could move the vessel in any direction. *(Photo courtesy of Victor S. Soleto, Deep Sea Drilling Project)*
(b) *JOIDES Resolution*, replaced the *Glomar Challenger* as the new drilling ship for the Ocean Drilling Program. *(Photo courtesy of the Ocean Drilling Program)*

Theory of Plate Tectonics and much more…

http://en.wikipedia.org/wiki/Soviet_submarine_K-129_(1960)

International Observational Programs

JGOFS

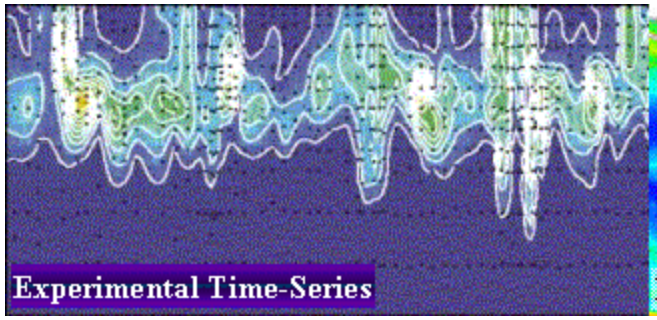
The Joint Global Ocean Flux Study (JGOFS)

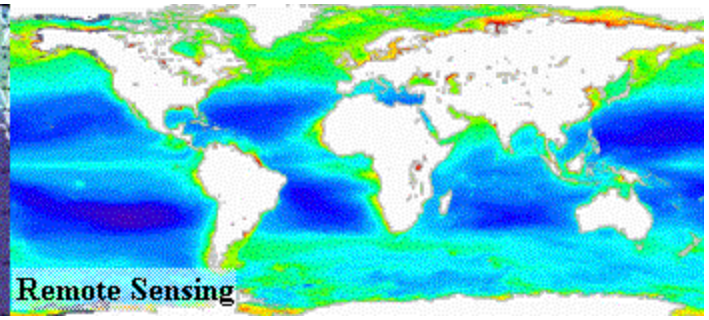
was launched in 1987 at a planning meeting in Paris

The Operational Goal of JGOFS :

Spatial Scale: regional to global
Temporal Scale: seasonal to interannual

1) Fluxes of carbon between the atmosphere-surface ocean-ocean interior.
2) Sensitivity to climate changes





International Observational Programs

The World Ocean Circulation Experiment 1990-1998

http://woce.nodc.noaa.gov/wdiu/

http://www-pord.ucsd.edu/whp_atlas//pacific/p03/sections/printatlas/P03_OXYGEN_final.jpg

International Programme on Climate Variability and Predictability, 1995-present

http://www.clivar.org

http://www.clivar.org/publications/other_pubs/other_pubs.php

World Climate Research Programme

http://wcrp.wmo.int

US Programs sponsors

Incredible amount of resources!

National Science Foundation
WHERE DISCOVERIES BEGIN

http://www.nsf.gov/

e.g. GLOBEC http://www.pml.ac.uk/globec

National Oceanic & Atmospheric Administration
U.S. Department of Commerce

http://www.noaa.gov

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
EXPLORE. DISCOVER. UNDERSTAND.

http://nasascience.nasa.gov/earth-science/oceanography

Office of Naval Research

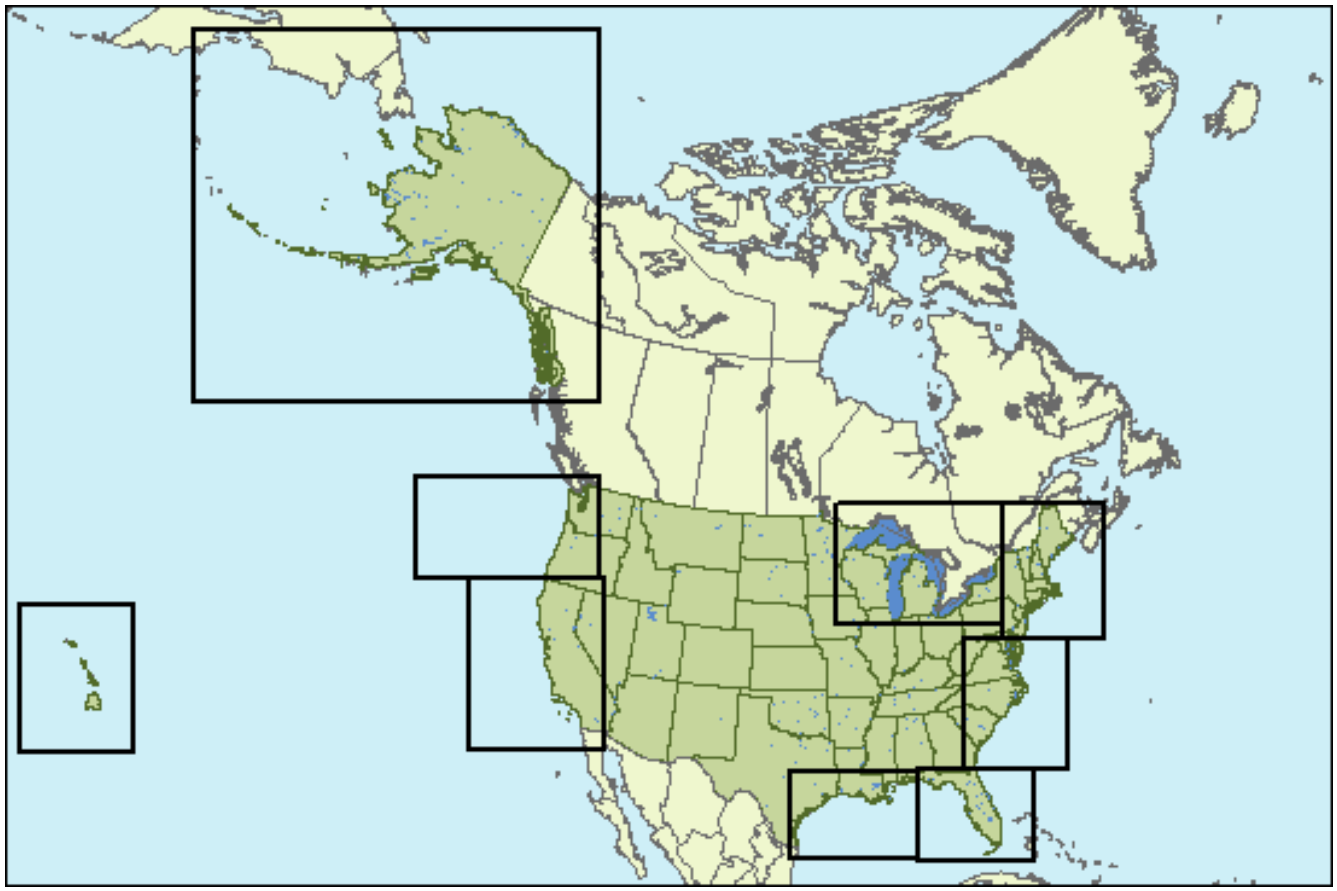
http://www.onr.navy.mil/focus/ocean/habitats/default.htm

U.S. Coastal Observing Systems

NOAA Coastal Services Center
LINKING PEOPLE, INFORMATION, AND TECHNOLOGY

National Science Foundation
WHERE DISCOVERIES BEGIN

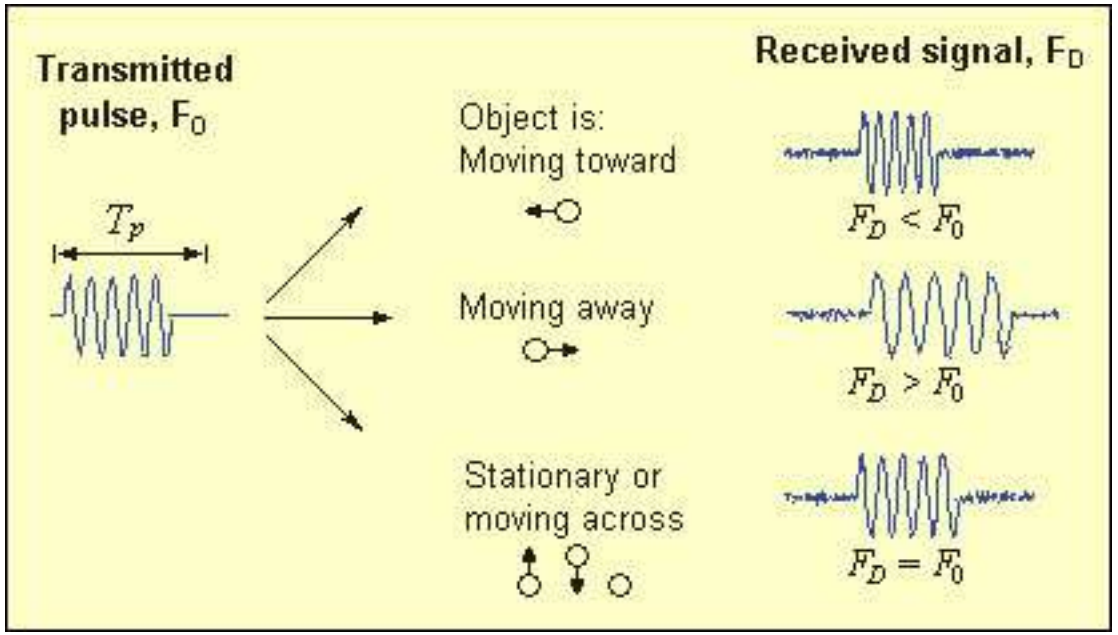
http://www.csc.noaa.gov/coos



Tools for ocean observing

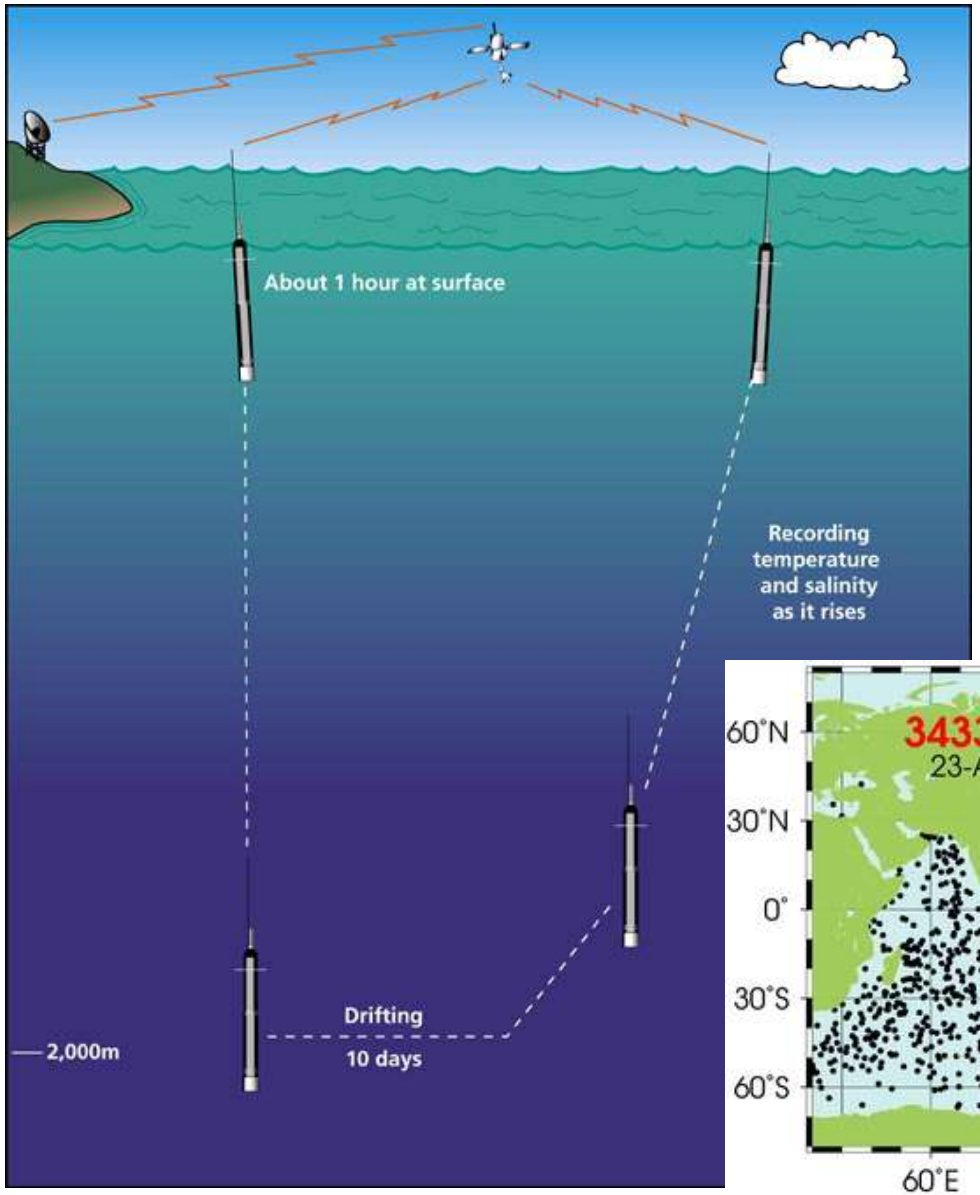
very good web-site→ http://www.whoi.edu/science/instruments/

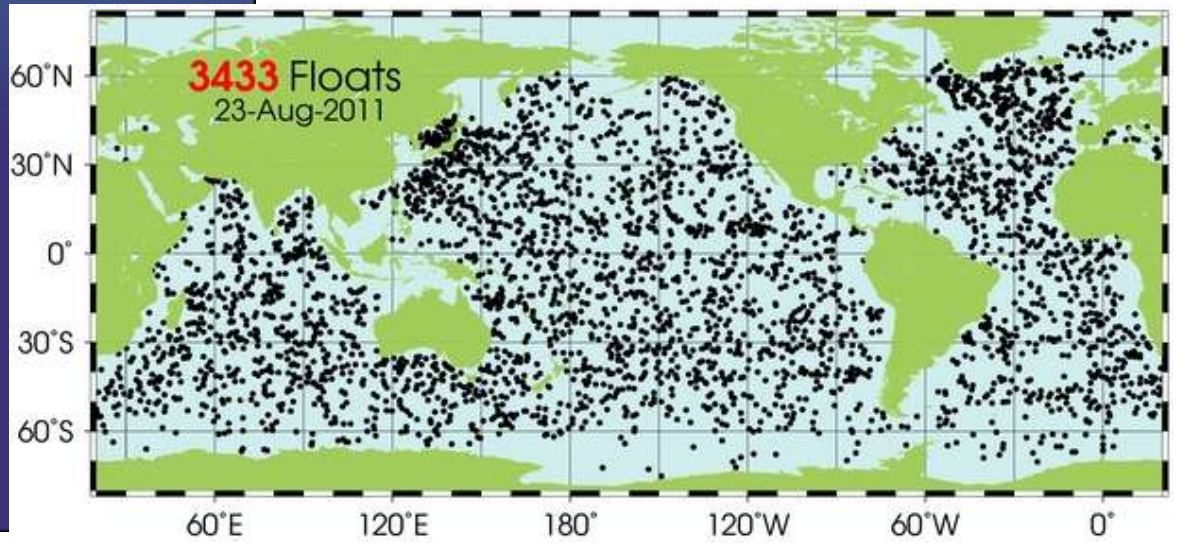
1) Acoustic Doppler Current Profiler (ADCP): measure velocity in ocean by pinging sound waves and analyzing the return wave



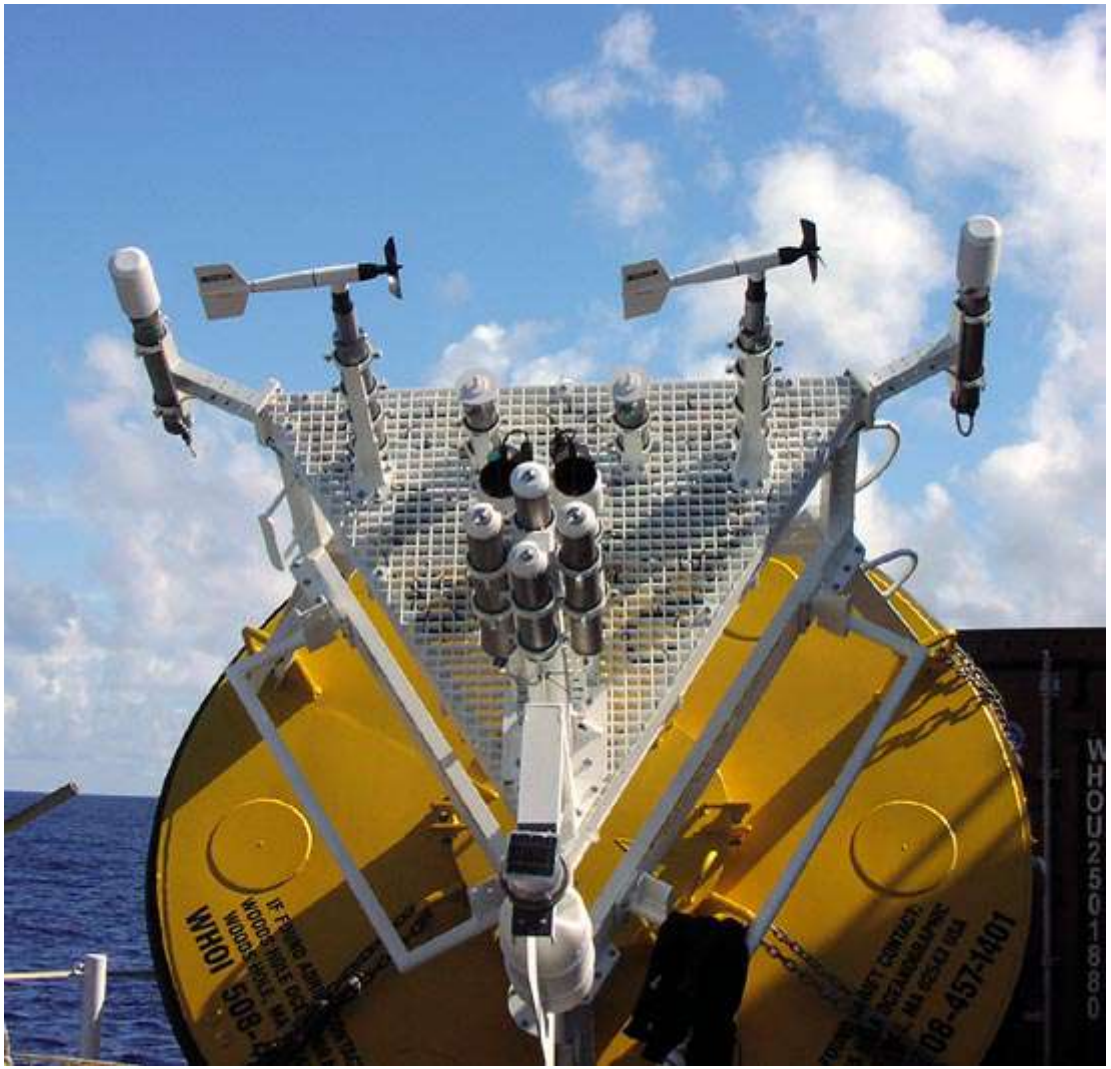
*** you are responsible for instruments shown in red**

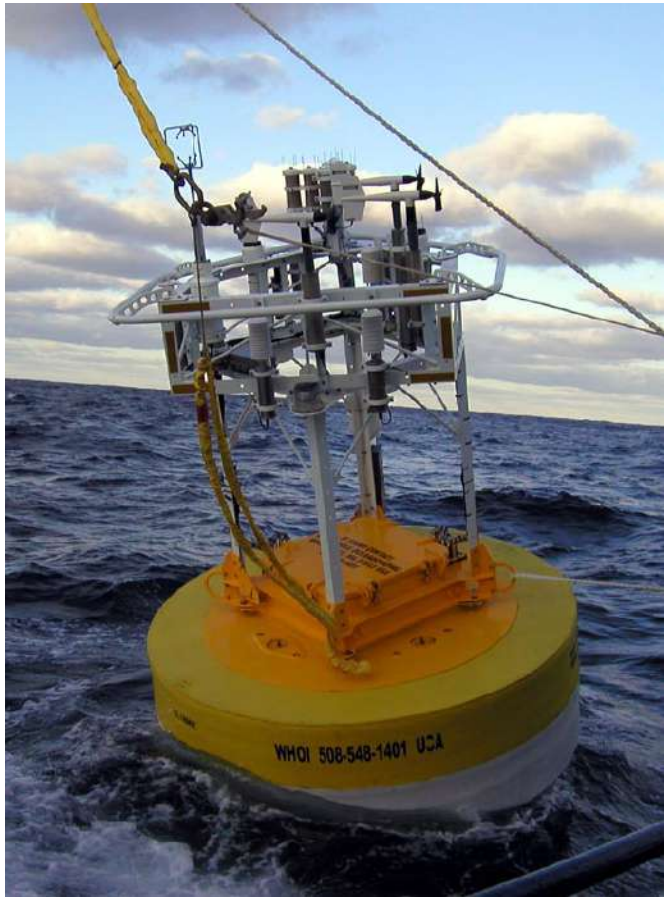
2)ARGO floats: measure ocean T and S while drifting with ocean currents, surface regularly to communicate with satellites to transmit data



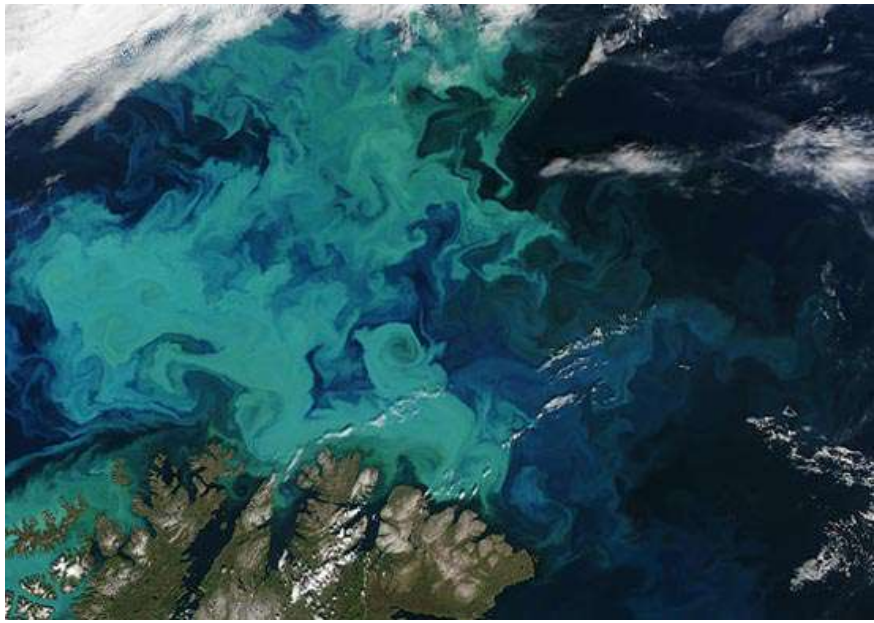


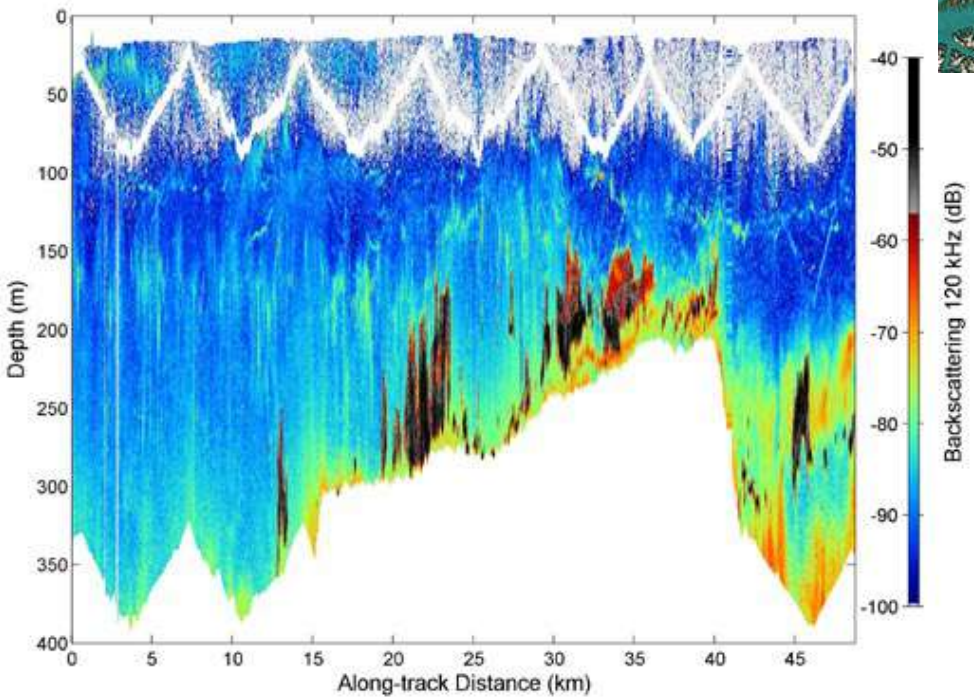
3) Air-Sea Interaction Meteorology (ASIMET): measure ocean T and S, atmospheric wind, pressure, radiation, and precipitation; usually on oceanic buoys or research ship



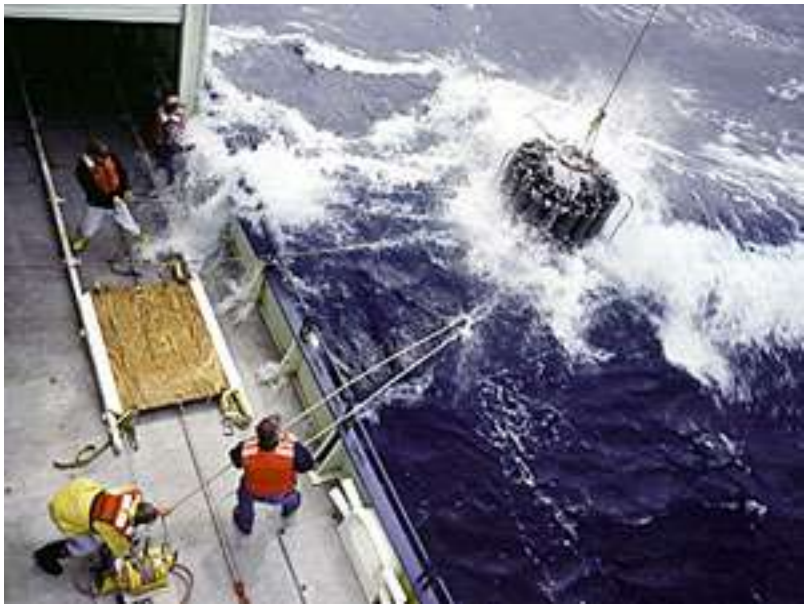


4) **BIOMAPPER: studies plankton via sonar, video, and environmental measurements**



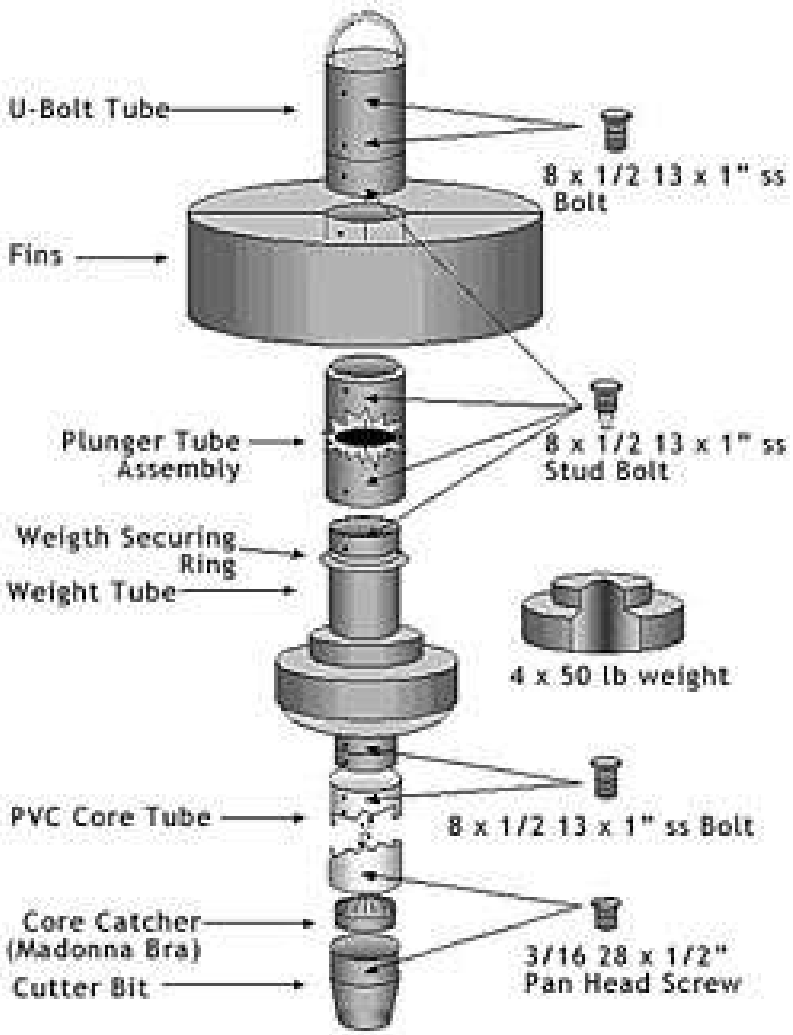


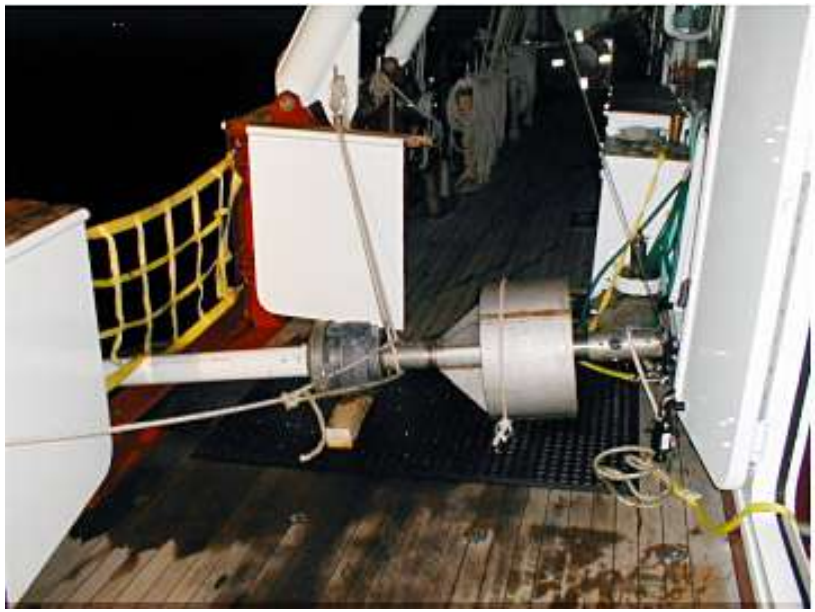
5)Conductivity-Temperature-Depth (CTD): measures T and S (density)in ocean



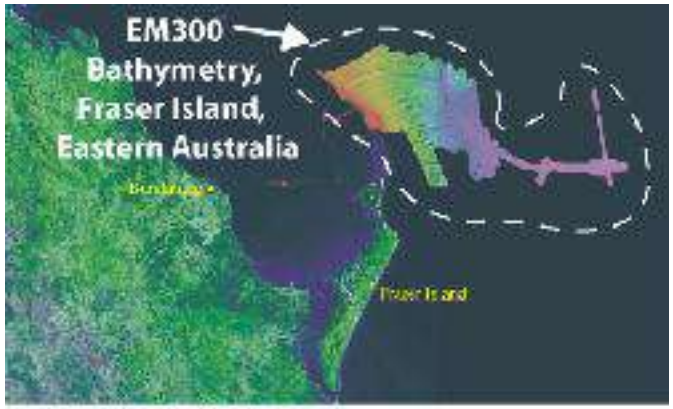
deployed off ship usually;
data fed back to ship in realtime
Niskin bottles sample ocean water at predetermined depths
“casts” can take many hours

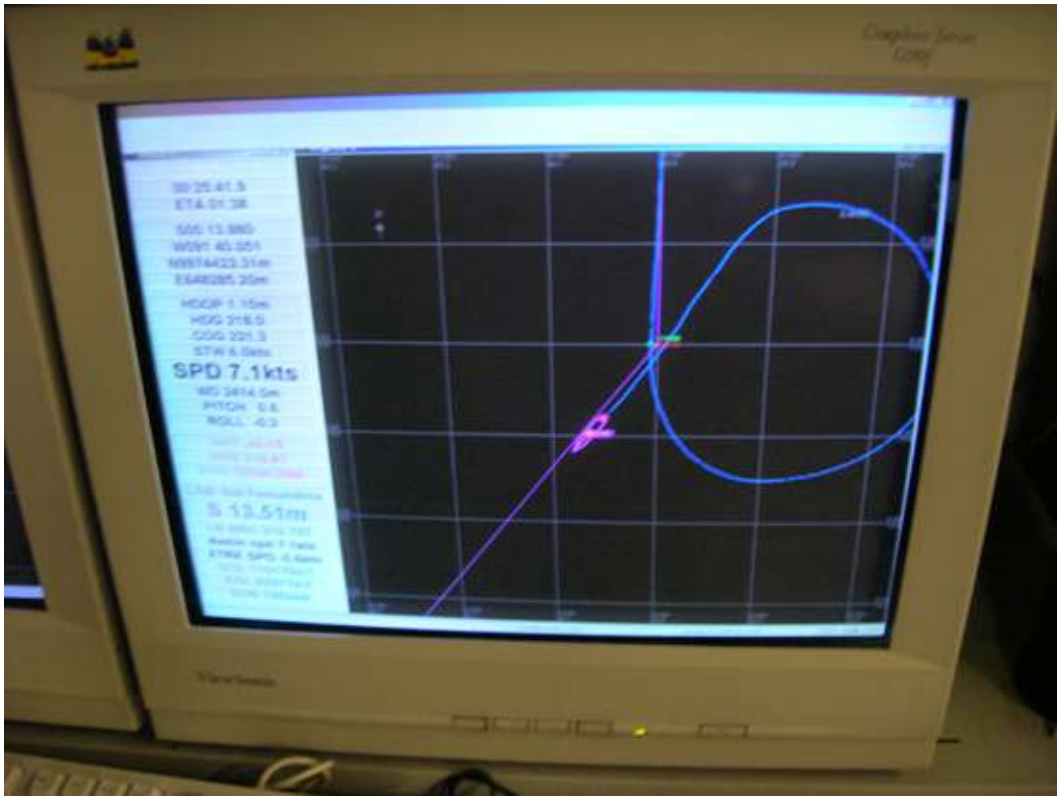
6) Gravity Corer: recover sediment core from ocean bottom





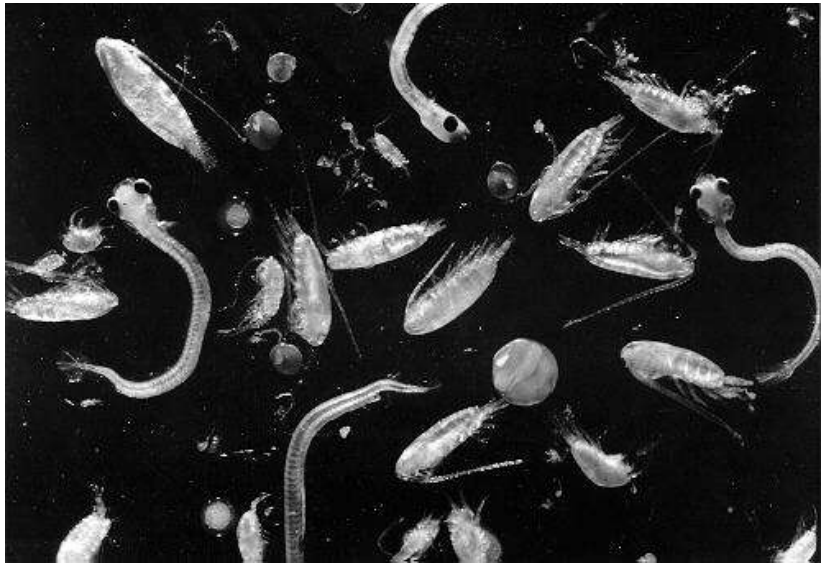
7) Multi-beam Echo Sounder: measure ocean bathymetry with ship (10-5000m)



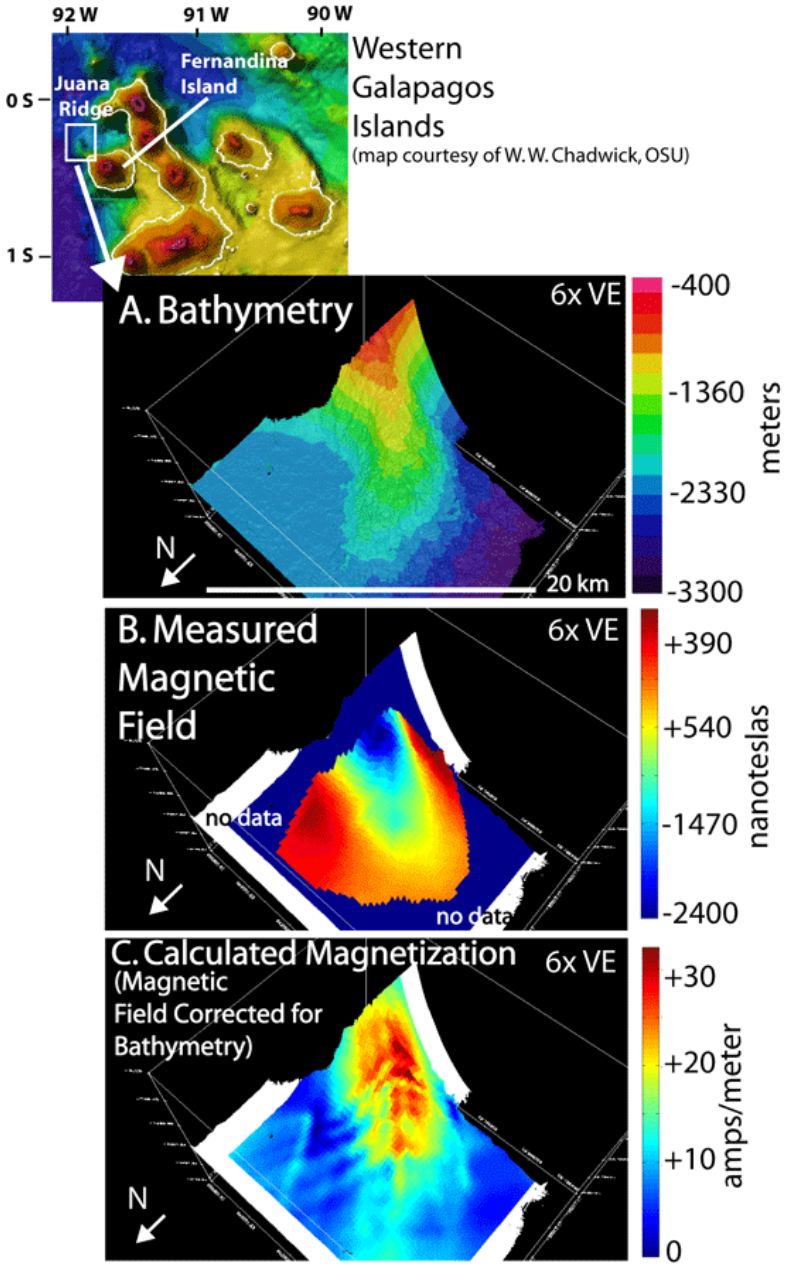


-like mowing the lawn: be sure you have overlapping "swathes"

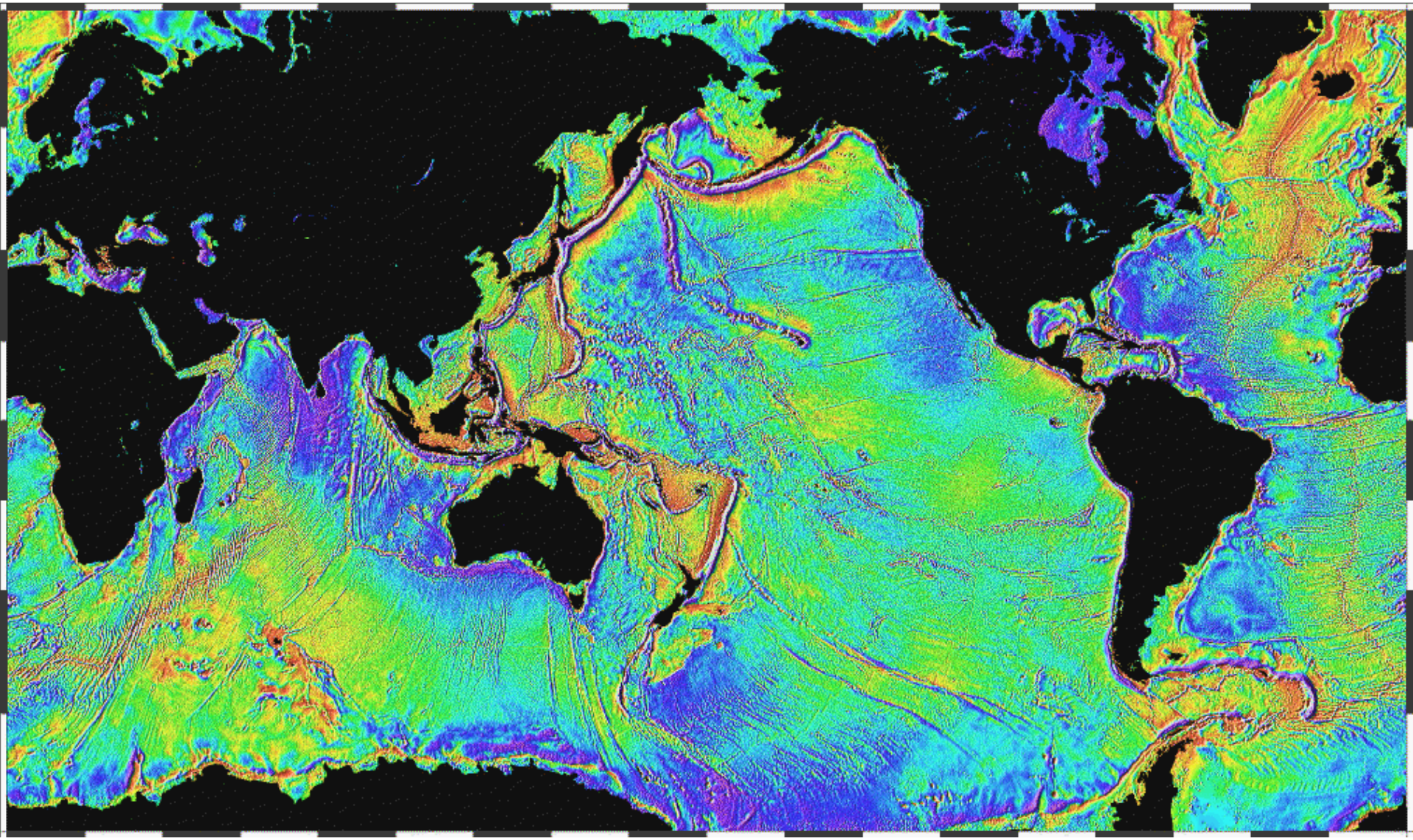
8) MOCNESS: multiple open and closing net with an environmental sampling system; used to collect plankton



9) Magnetometer: measure magnetic field in ocean

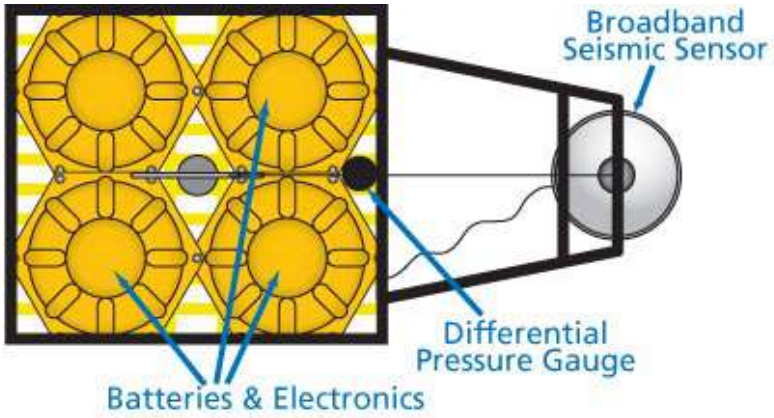


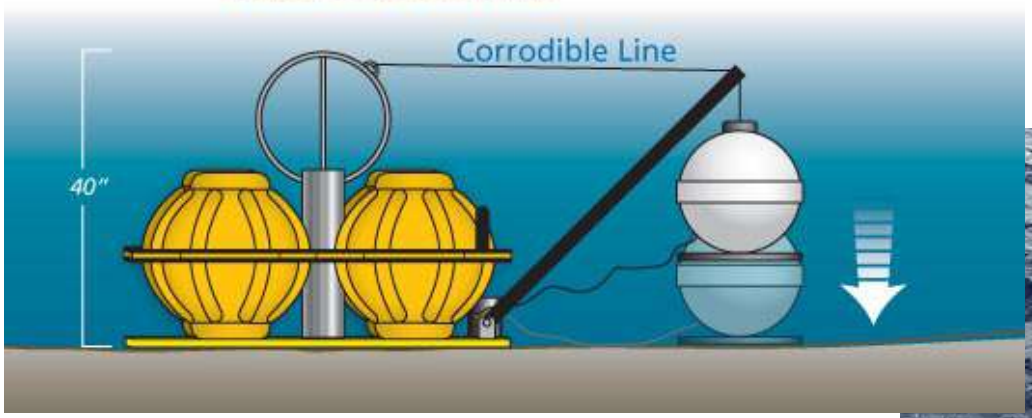
10) Seafloor mapping from satellite radar altimetry & ships soundings



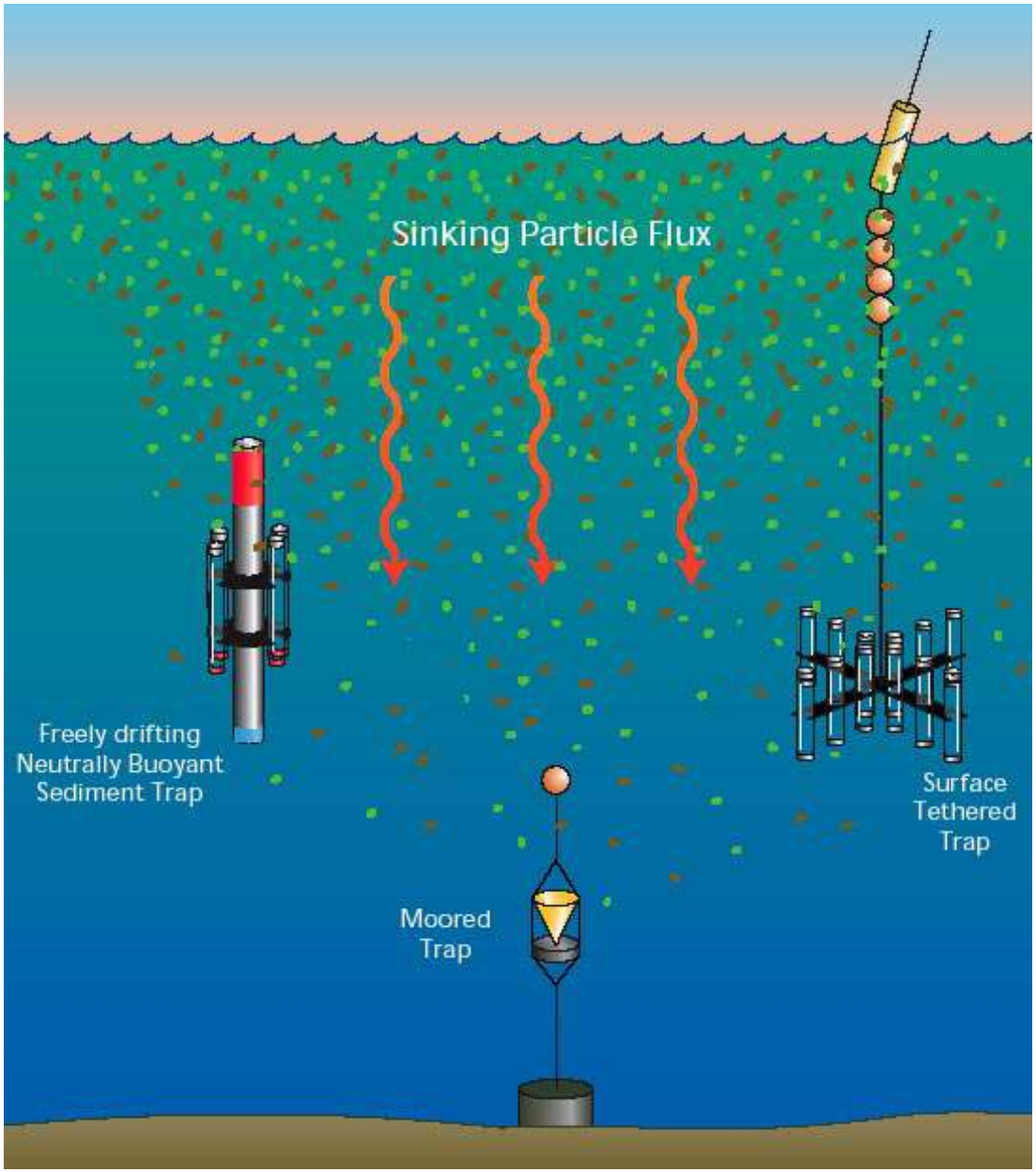
Smith and Sandwell, 1997

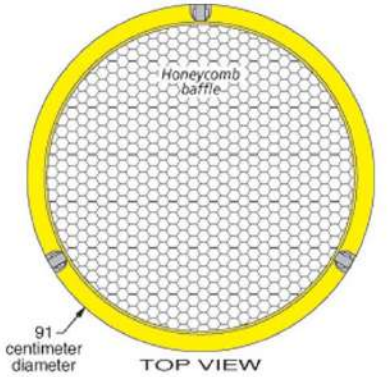
11) Ocean Bottom Seismometer: measure underwater earthquakes

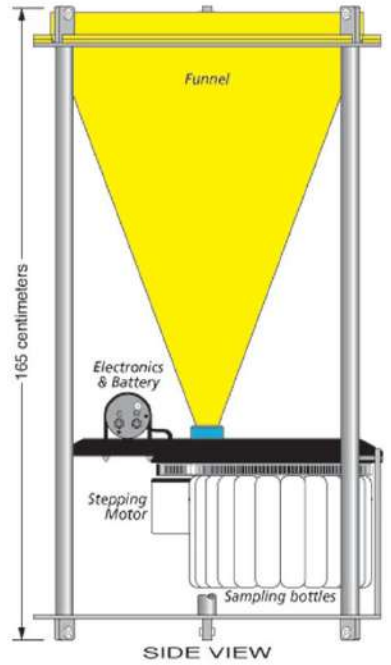


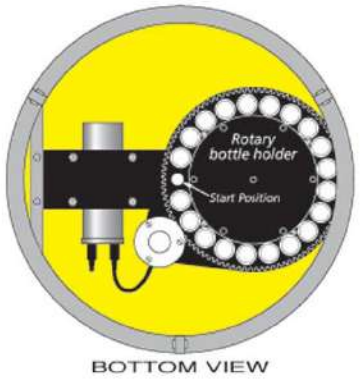


12) Sediment trap: collect falling sediments in ocean

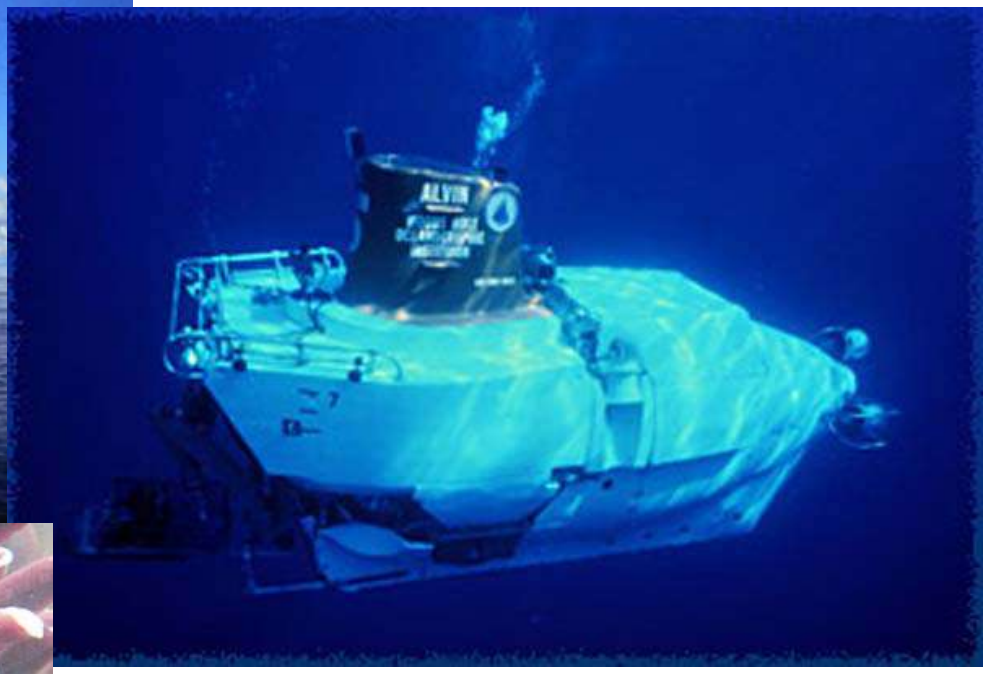








13) Alvin: a 3-person submersible that can dive to 4.5km



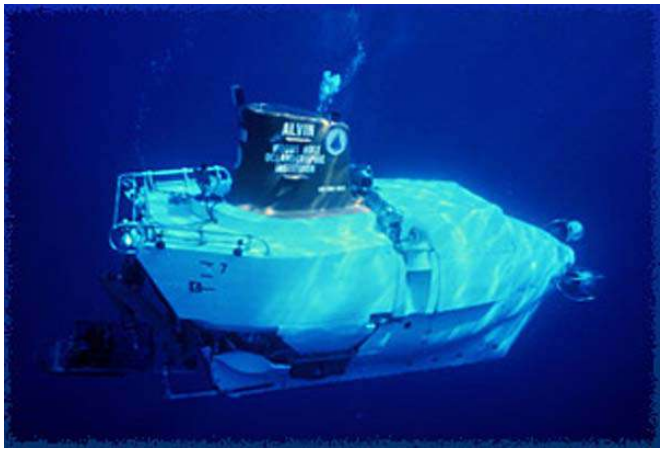
1977: discovered hydrothermal vents

Technologies for ocean observing

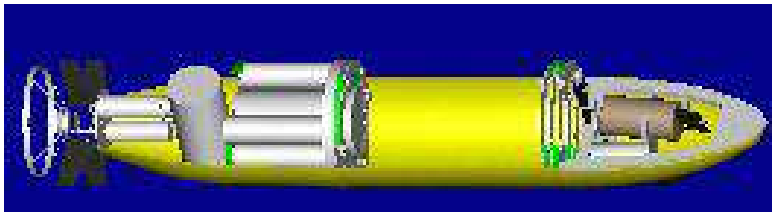
Remote Sensing/Satellite Imagery:
Geostationary Server - http://www.goes.noaa.gov
Satellite significant events: http://www.osei.noaa.gov
National Geophysical Data Center: http://www.ngdc.noaa.gov/ngdc.html

Floating devices in the ocean:
Argo FLoats - http://www.argo.ucsd.edu
Drifter Programs: http://www.aoml.noaa.gov/phod/graphics/pacifictraj.gif

Submarines &
Remotely Operated Vehicles (ROVs) :
Amazing discoveries…
http://oceanexplorer.noaa.gov/technology/subs/rov/rov.html



Automated Underwater Vehicles (AUVs) :



SO MUCH DATA!!!

How to synthesize it?

Homework #1

http://o3d.org/eas-4300/hw/hw1.pdf