SMS 204: Integrative Marine Sciences II, Physics

- Instructors: E. Boss and L. Karp-Boss
- Credits: 2
- Meeting times: Mon. 8:00-8:50am – Little Hall, 120
- Labs: Aubert 488.
- TAs –Faith, Josephine and Gretchen.
- Lab manager/co-instructor: James Loftin
- Homework: submit to blackboard
- Assistance? Contact me, Jim or TAs.
- Email: emmanuel.boss@maine.edu
- http://misclab.umeoce.maine.edu/boss/classes/SMS_204/syllabus.htm

- Class philosophy
  - Physics and chemistry are needed to understand the environment organisms experience.
    - Learn basic concepts
    - Gain hands-on experience
    - Learn new skills and sharpen old ones
  - Create a supportive learning environment and a learning community

– Learn necessary skills:
  - Displaying data (graphing).
  - Analyze data (statistics).
  - Relate different data.
  - Understand how to report/compute uncertainties in data.
  - Improve your ability to convert units.
  - Working in groups.

- Knowledge base:
  - Understand fluids and life in a fluid environment.

- Expectations
  - Listen/interact in class. If you don't slow me with questions, I will charge on…
  - Come see me or a TA if you need to or drop me an email (no official office hours).
  - Homework (can work in groups, hand in *individual* work that is *not* identical)
  - Final exam – 3/9/2020

- Class notes (as opposed to an expensive textbook) are on-line. I expect you to read them *before* coming to class/lab.

- What is physics?
  - Physics is the science of matter, energy, space, and time.
  - The word physics is derived from Greek word fusis, meaning nature or natural things. As such, physics is defined as that branch of science, which studies natural phenomena in terms of basic laws and physical quantities.
  - Physics answer questions about the universe and the way elements of universe interact to compose natural phenomena.

This class will concentrate on:

- Fluids
- Density
- Pressure
- Buoyancy
- Viscosity
- Heat
- Light and Sound

- What do we need to know about the environment marine organisms experience?
- Choose a marine organism
- Provide physical characteristics of the environments which affect:
  - Reproduction (finding a mate)
  - Feeding (finding food)
  - Getting rid of waste products
  - Avoiding being eaten (escape)

- Some basic concepts we need before we get into physics:
  - Dimensions and units (How much?)
  - Coordinate system (Where?, when?)
  - Accuracy vs. precision (How well do we know something?)
  - Statistics: description of data.

- Dimensions and Units

  - T, L & M (sec, m & Kg, SI units).
  - Consistency in dimensions is crucial in physics and can highlight dependencies (dimensional analysis).
  - Table with dimensions of different physical quantities in the notes.
  - Unit mistakes can be very costly.

By Robin Lloyd
CNN Interactive Senior Writer

9-30-1999

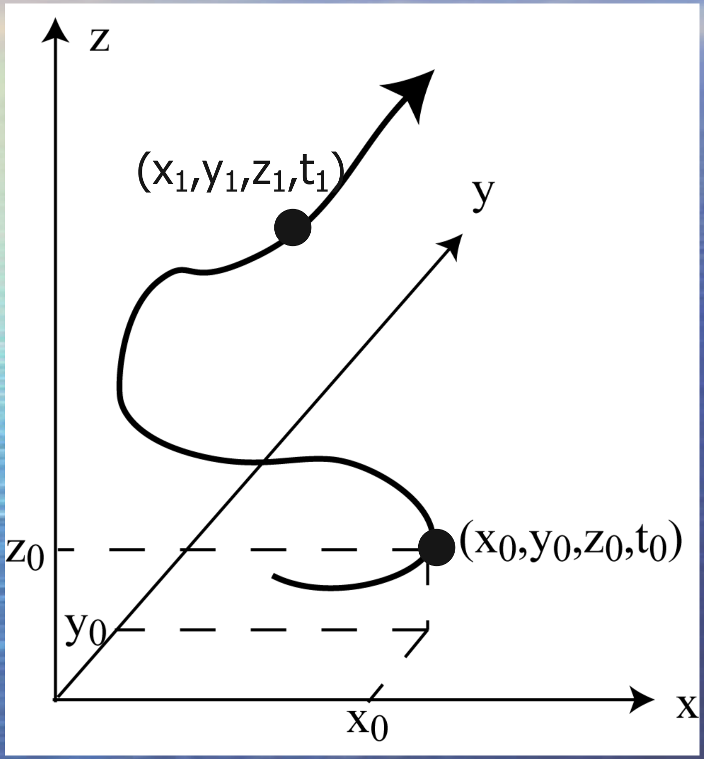
(CNN) -- NASA lost a $125 million Mars orbiter because a Lockheed Martin engineering team used English units of measurement while the agency's team used the more conventional metric system for a key spacecraft operation, according to a review finding released Thursday.

- Dimensions vs. Units
  - Dimensions are general and do not change with the system of measurements.
  - Mass, Length, Time and Number [M, L, T, N] used in this class;

  One kind of a unit for N is the mole=6.022 x 10^{23}.

  A unit is the "yardstick" (e.g. lb, g, kg).

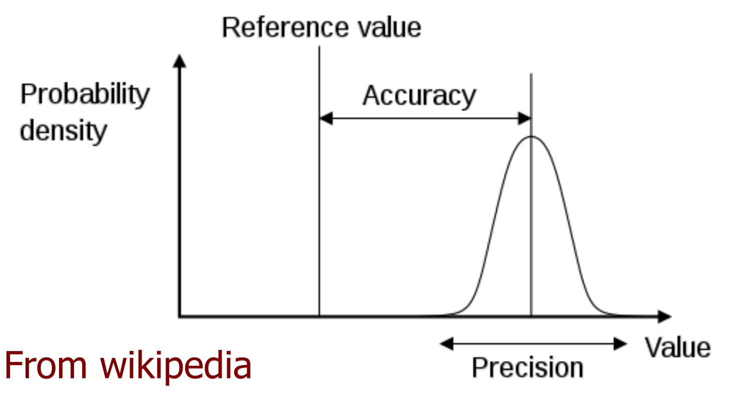
Coordinate system, and some basic notation. Think: GPS



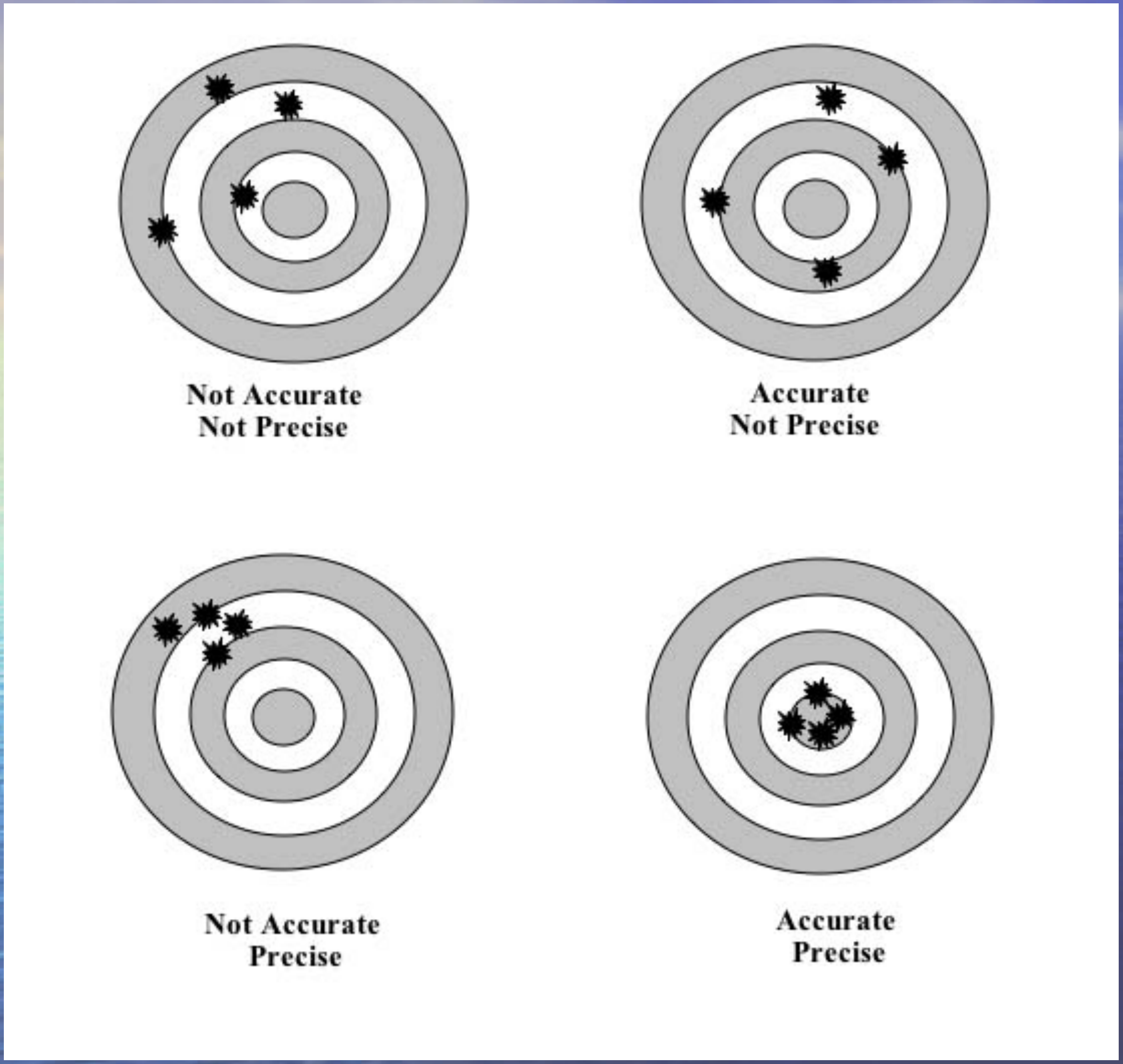
$$L = \sqrt{(x_1 - x_0)^2 + (y_1 - y_0)^2 + (z_1 - z_0)^2}$$

Vectors and scalars

- Measurements, precision, and accuracy
  - Every measurement has an <u>uncertainty</u>
  - May depend on measuring device
  - Two sources for uncertainty:
    - <u>Precision</u>: how well can we reproduce a measurement
    - <u>Accuracy</u>: how close we are to the 'true' value



From wikipedia



Which is better Being inaccurate or imprecise?

How can we improve our estimate of a quantity with imprecise measurements (standard error of the mean)?

How can we improve our estimate of a quantity with inaccurate measurements?

Significant digits

http://celebrating200years.noaa.gov/magazine/tct/accuracy_vs_precision_556.jpg

Basic statistics:

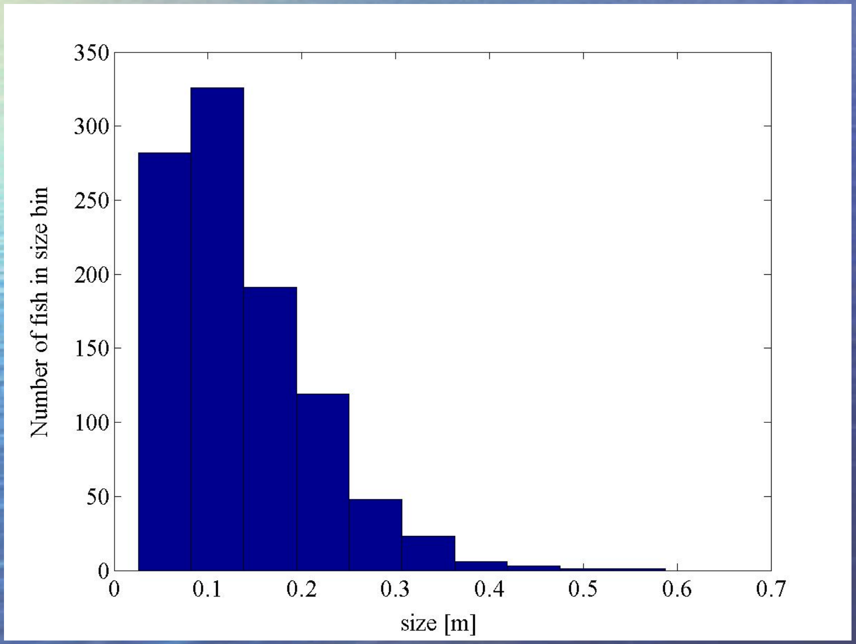
Two different ways to describe observations:

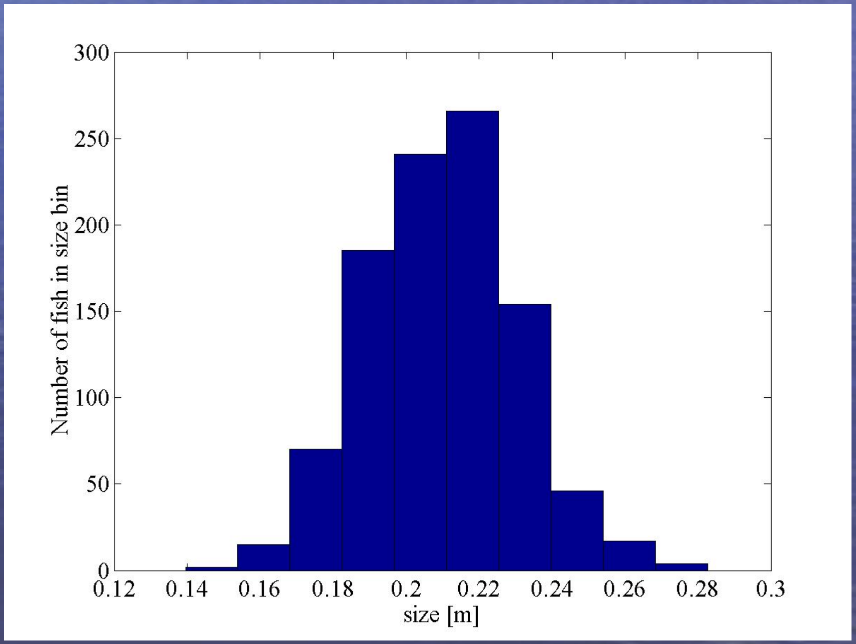
Parametric —Applied when it is known that the underlying distribution can be described by a small number of parameters. For example, the normal distribution is completely described by a mean and a variance.

Nonparametric—Applied when the underlying distribution is unknown or too complex for simple description. Nonparametric statistics make extensive use of ranking and percentiles, for example the median (the 50th percentile)

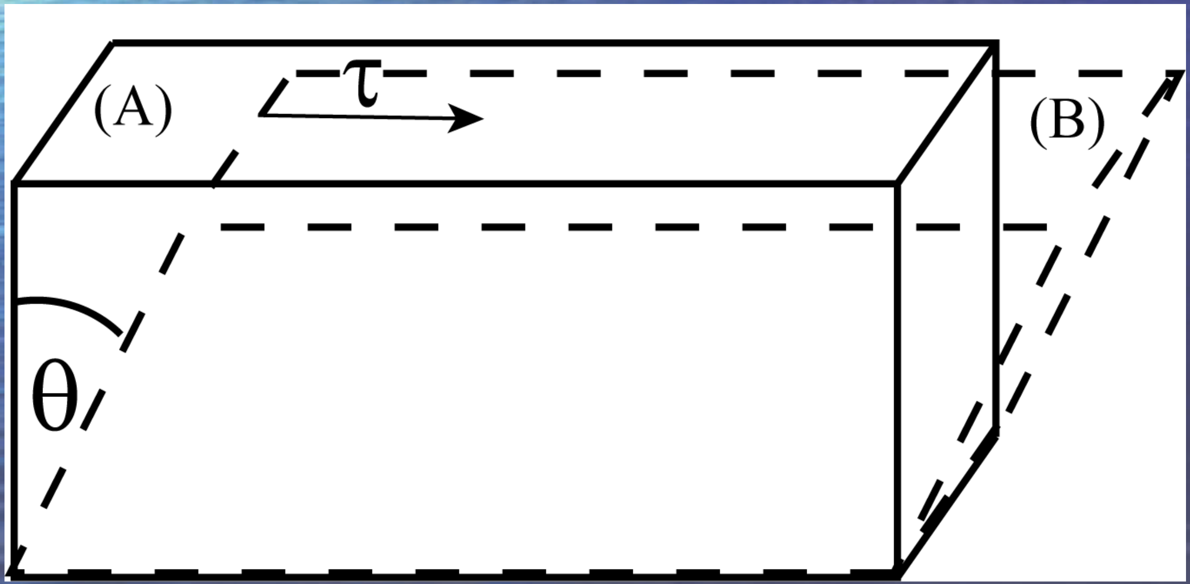
Basic statistics:
A mathematical set of tools to describe observations.

Two different observation pertaining to a hypothetical distribution of the size of adult salmon, both having the same average size:





- Solids and fluids
  - Self supporting solids vs. container supported fluids.
  - Liquid vs gas (fill or not the container in which they are).
  - Different response to an applied stress (Force/Area):
    - Solids (Hookean): $\tau = G\theta$:
      constant force → constant deformation
    - (Newtonian) Fluids: $\tau = \mu d\theta/dt$
      constant force → constant rate of deformation



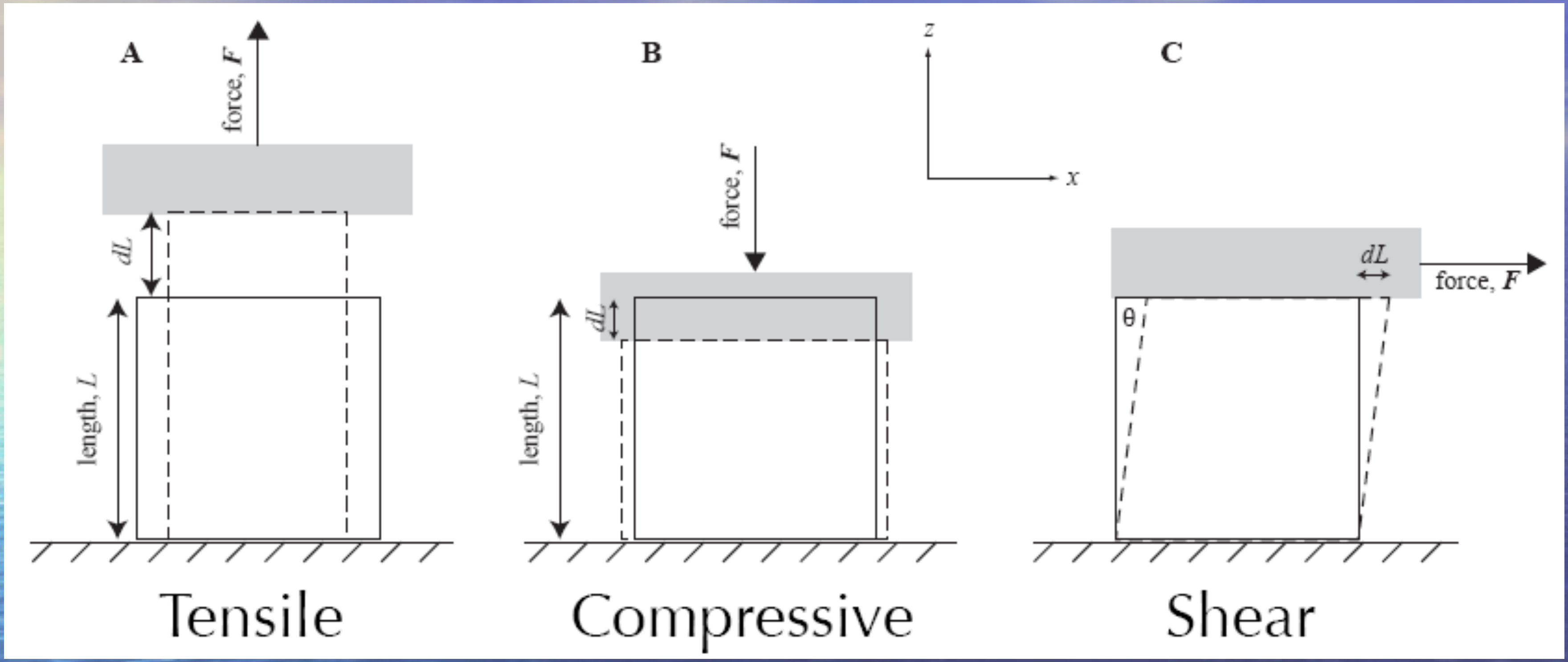
Non-Newtonian fluid – [movie](https://www.youtube.com/watch?v=RIUEZ3AhrVE)
https://www.youtube.com/watch?v=RIUEZ3AhrVE

- Continuum hypothesis: we treat fluids as continuous medium disregarding their molecular nature.

- Some physical properties have their origins in the molecular nature of the fluid (e.g. density, temperature and viscosity).

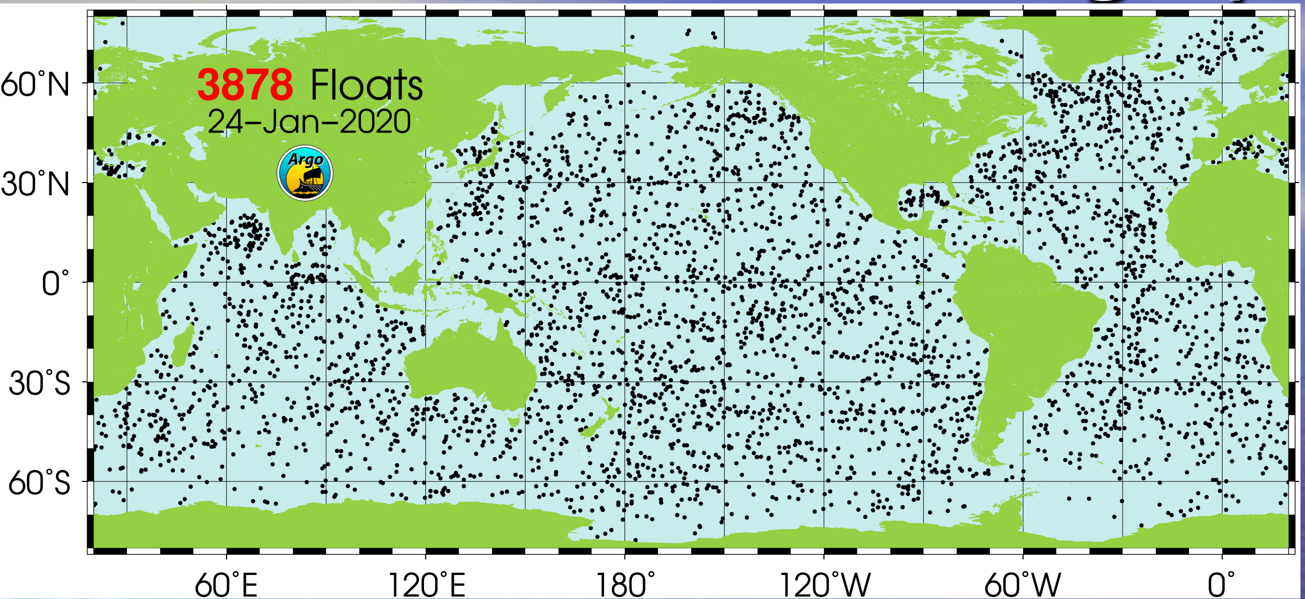
- Fluids ‘stick’ to surfaces (no mater how smooth): No-slip condition.

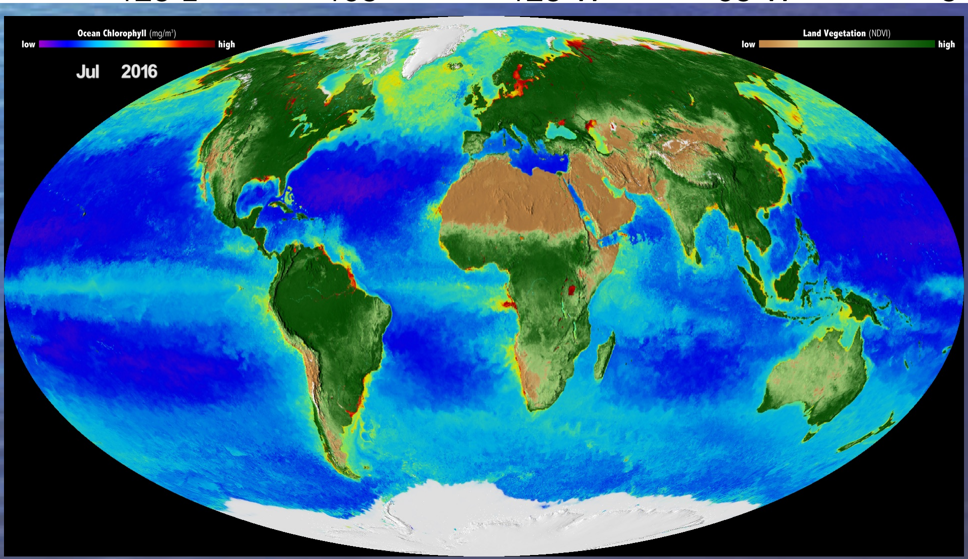
Stress (Force/area) and Strain (dL)

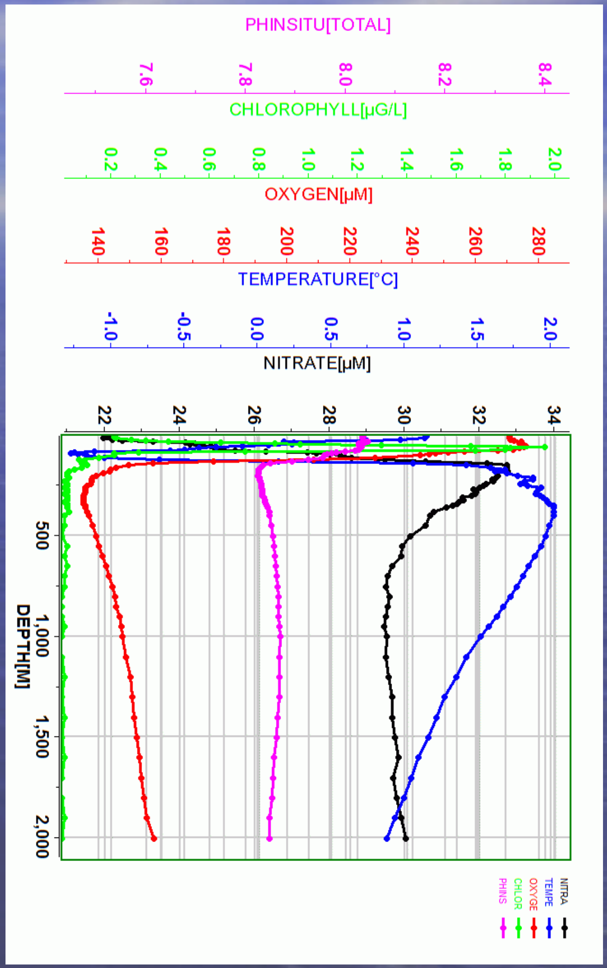


- Convention makes tensile stresses positive and compressive stresses negative.

Global observing systems







Summary:

- We should study physics to better understand the biology of marine organisms.
- We need to keep track of units of physical quantities.
- We need to keep track of uncertainties in physical measurements.
- It is convenient to treat liquids as continuous medium (without holes between the molecules).
- Liquids differ from solids and gases in fundamental ways.
- Observing systems provide continuous global data on the physical, chemical and biological state of the ocean.