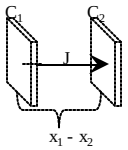
Diffusion in Water

- Molecular versus advective transport (also referred to as eddy diffusion or transport diffusion)
- Fick's Law Diffusion = constant * ? C/ ? X



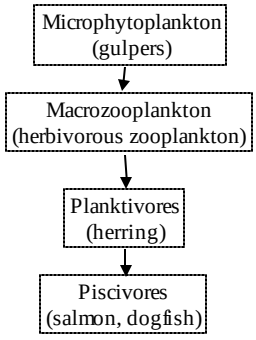
Diffusion Boundary Layer

- Similar to the flow boundary layer, but defined by the region where molecular diffusion dominates
  - Brownian motion
  - Nanometers/second
- Biogeochemical constraint as well as a physiological constraint
- As opposed to transport diffusion, advective transport, eddy diffusion – the transport of materials in water currents
  - Laminar and turbulent flow
  - cm to m /second
- Why do you stir your tea or coffee when you add sugar?
- How long would it take a sugar cube to dissolve…?
  - In an unmixed glass? Is transport diffusion occurring?
  - In a stirred glass?
  - In a glass of agar?

Surface Area:Volume alters efficiency of diffusion

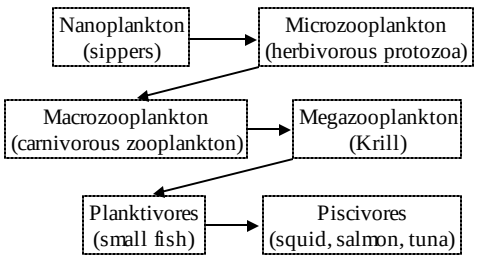
- Consider two cubes, one 1 µm and one 1000 µm on a side
- Surface areas are 6 and 6000000 μm^2
- Volumes are 1 and 1 billion μm^3
- Sa/V is 6 versus 0.006, respectively
- How do large organisms deal with diffusion?

Continental Shelf Pelagic Environment
(only 3 trophic links)

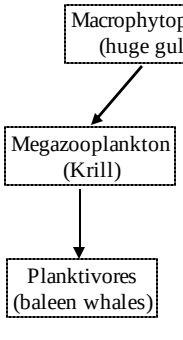


Number of trophic levels in ecosystems influences the biomass of large animals that is supported by a given amount of 1° production

Open Ocean has long food web (5 trophic links)



Upwelling Region Ecosystem (1 or 2 tropic chains)



Secondary (Fish) production

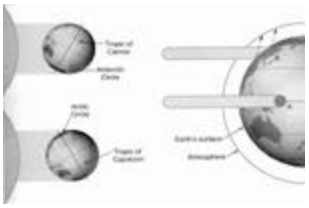
Environment	Mean 1° Productivity ($gC/m^2/yr$)	Trophic Links	Ecological Efficiency	Fish Production ($mgC/m^2/yr$)
Oceanic	50	5	10	0.5
Continental Shelf	100	3	15	340
Upwelled	300	1.5	20	36,000

from Ryther 1969

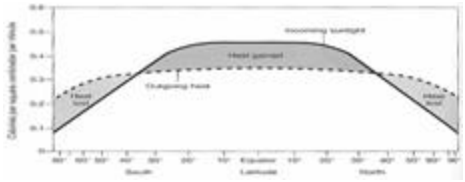
What will Fe fertilization do to 2° productivity?

Light and Heating of Water

- Photosynthesis driven by light
- UV increases are important
- Water is heated by light

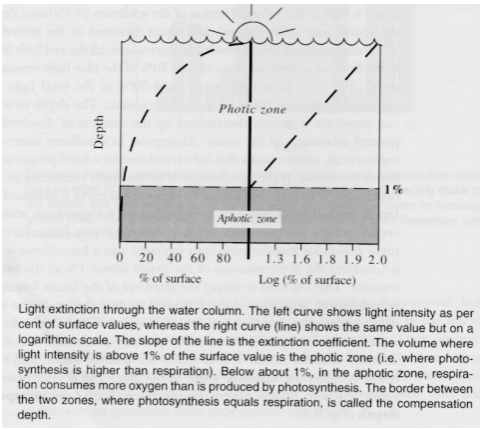


What Happens When Sunlight Strikes Earth



Light Attenuation is Logarithmic

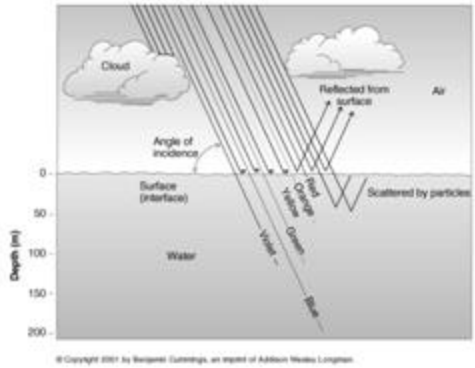
- Assume 1/10th is left after 1 m, 1/100th after 2 m, 1/1000th after 3 m, etc.
- Attenuation coefficient ? describes how rapidly light is attenuated
- ? = (ln I_1- ln I_2)/(z_2 - z_1)



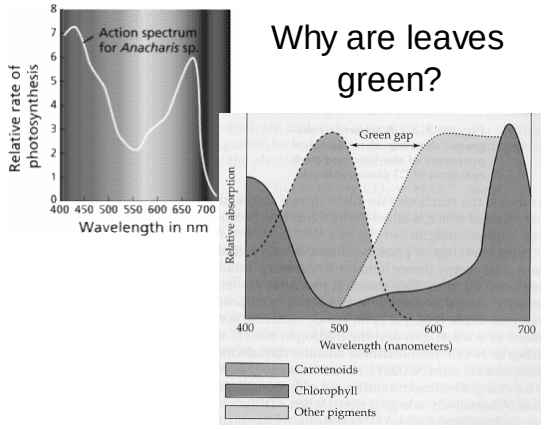
Light extinction through the water column. The left curve shows light intensity as per cent of surface values, whereas the right curve (line) shows the same value but on a logarithmic scale. The slope of the line is the extinction coefficient. The volume where light intensity is above 1% of the surface value is the photic zone (i.e. where photosynthesis is higher than respiration). Below about 1%, in the aphotic zone, respiration consumes more oxygen than is produced by photosynthesis. The border between the two zones, where photosynthesis equals respiration, is called the compensation depth.

Specific Wavelengths of Light can be Attenuated Selectively

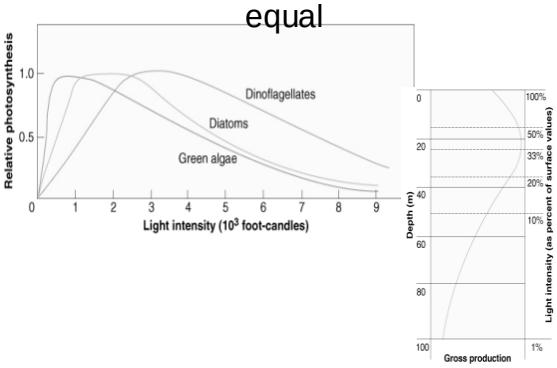
- Pure water transmits blue light most efficiently
- Chlorophyll absorbs red and blue light most efficiently
- Cyanobacteria have pigments that can use green light



Why are leaves green?

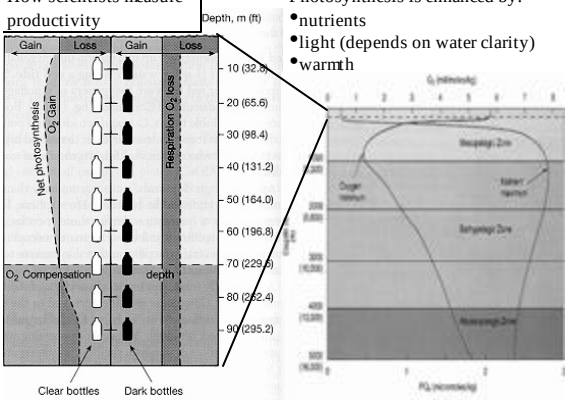


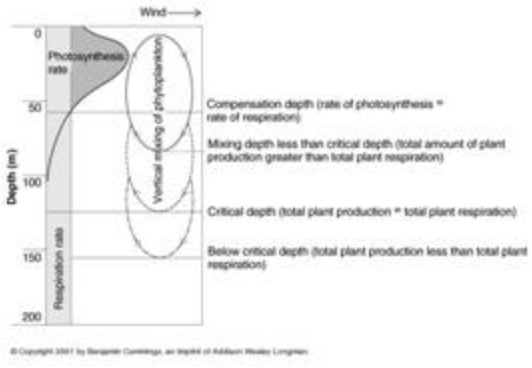
Not all phytoplankton are create equal



How scientists measure productivity

Photosynthesis is enhanced by:
- nutrients
- light (depends on water clarity)
- warmth





Questions for thought?

- Why are the oceans blue?
- Why do aquatic insects in torrential streams have reduced gills?
- Why might large rivers have greater attenuation coefficients than large lakes?
- Why are lakes the color they are, fish the color they are, and fish lures the color they are?
- Why do shaded shorelines have vegetation, but shaded shallow water do not?

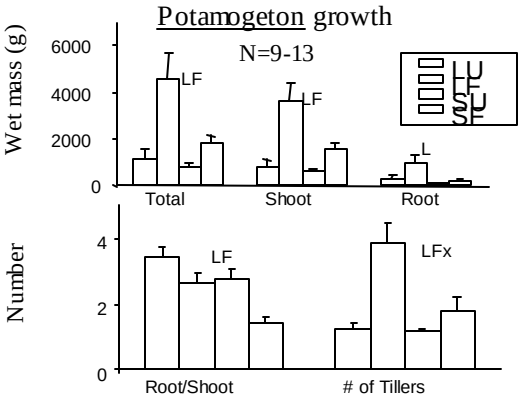
Effect of light and nutrient availability on the growth, carbon/nitrogen balance, phenolic chemistry, and resistance to herbivory in two freshwater macrophytes

Greg Cronin, David M. Lodge, and Sarah Johnson

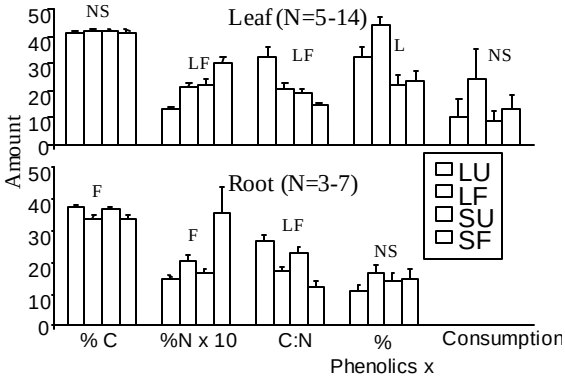
Phenotypic plasticity

- Phenotypic plasticity is the ability of an organism to alter its phenotype in response to environmental factors
- These inducible changes are generally believed to have an adaptive significance, allowing organisms to respond to environmental variability on relatively short time scales
- Several ecological theories (e.g., allocation models, chemical defense theories) have been proposed to explain the adaptive significance of phenotypic plasticity

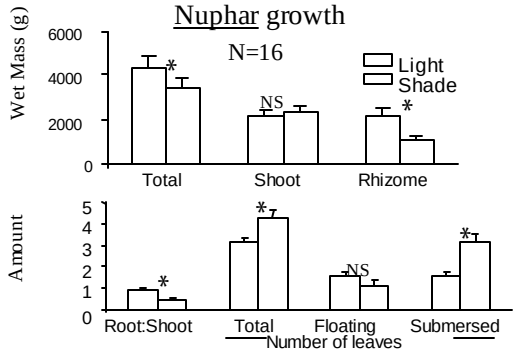
Potamogeton growth



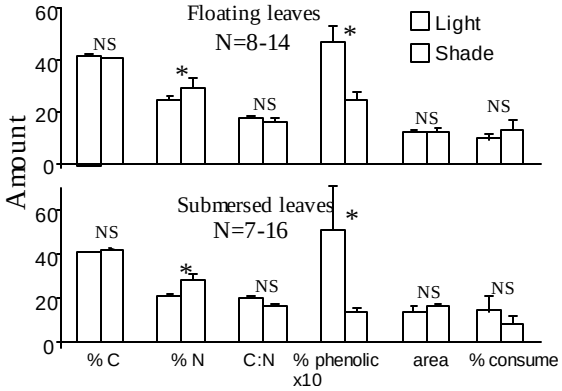
Potamogeton chemistry and palatability



Nuphar growth



Nuphar leaf chemistry and consumption



Conclusions

- *Potamogeton* and *Nuphar* responded similarly to reduced light availability, and in a manner generally consistent with the CNBH
- *Nuphar* produced more submersed leaves at reduced light levels
- *Potamogeton* and *Nuphar* responded very differently to nutrient enrichment: *Potamogeton* flourished while *Nuphar* perished
- *Potamogeton* grew better at higher nutrient levels, allocated a greater proportion of this growth to above-ground biomass, and produced more phenolics (contrary to the CNBH)
- The changes in tissue quality caused by the manipulations resulted in no significant changes in herbivore relations
- The phenotypic plasticity observed probably has adaptive significance