Challenges to Marine Life – Read Knauss (pp. 134-135); also read these headings at Wikipedia: 1) Photic Zone and 2) Primary Production

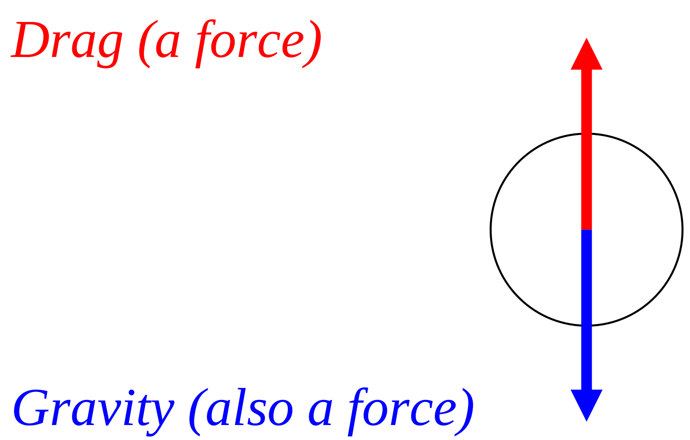
http://en.wikipedia.org/wiki/Photic_zone

We start with the concept of settling and then predation (next week)

Settling - *Most of the marine biomass is phytoplankton. For these guys to "do their thing" they must remain within the photic zone. If they are negatively buoyant (most are) then they need to expend energy to "stay in the light." For some this involves propulsion, for others it involves making and storing low density materials (fats, oils, air, etc.)*

We assume the phytoplankton are spheres. Also, we assume the spheres are negatively buoyant and thus setting under the influence of gravity.

Phytoplankton sphere with radius "r"



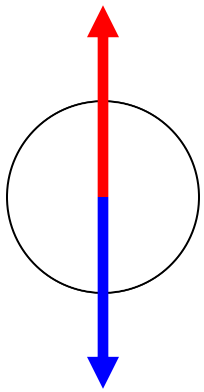
Note:

If Drag>|Gravity|, the particle *accelerates* upward

If Drag<|Gravity|, the particle *accelerates* downward

Drag (a force)

A sphere with radius "r"



Gravity (also a force)

Here is how we formulate the forces:

Gravity = $\frac{4}{3} \cdot \pi \cdot r^3 \cdot (\rho - \rho_S) \cdot g$

The "Drag" formulation depends on how the water flows around the sphere. If the flow around the sphere is laminar (non-turbulent) then Stokes Law tells us how to formulate the Drag:

Drag = $-6 \cdot \pi \cdot r \cdot \mu \cdot w$

With the assumption of laminar flow (which implies that the Reynolds number is less than 1) then the equation of motion for the sphere is as follows

$$\left(\frac{4}{3} \cdot \pi \cdot r^3 \cdot \rho_S\right) \cdot \frac{dw}{dt} = -6\pi \cdot \mu \cdot r \cdot w + \frac{4}{3}\pi \cdot r^3 \cdot (\rho - \rho_S) \cdot g$$

Assuming (a third assumption!) force balance, there is a “balancing” velocity, we call that velocity the terminal velocity or settling velocity

$$0 = -6\pi \cdot \mu \cdot r \cdot w_t + \frac{4}{3}\pi \cdot r^3 \cdot (\rho - \rho_s) \cdot g$$

We solve for that velocity

$$w_t = \frac{2 \cdot r^2 \cdot (\rho - \rho_s) \cdot g}{9 \cdot \mu}$$

Note: Typically, $(\rho - \rho_s) < 0$, so the particle settles.

$$| w_t | = \frac{2 \cdot r^2 \cdot |\rho - \rho_s| \cdot g}{9 \cdot \mu}$$ terminal or settling velocity