GLG/BIO 394
Oceanography Class Homework #6 –SOLUTION KEY

1. What is the average efficiency of energy transfer between trophic levels? Use this efficiency to determine how much phytoplankton mass is required to add *1 gram* of new mass to a killer whale, which is a third-level carnivore. Include a diagram that shows the different trophic levels and the relative size and abundance of organisms at different levels. How would your answer change is the efficiency were half the average rate, or twice the average rate?

Average efficiency = 10% between trophic levels. The gross ecological efficiency = E passed on to next higher trophic level / E aquired from trophic level below. In other words, $E_t = \frac{P_t}{P_t - 1}$. For a killer whale to gain 1 gram of mass, he must have eaten 10 grams of large fish that in turn ate 100 grams of smaller fish that ate 1000 grams of zooplankton that consumed 10000 grams of phytoplankton. If the energy efficiency rate was halved (5% instead of 10%), the killer whale would have to eat twice as much to gain 1 gram of mass. Therefore, the killer whale ate 20 grams of large fish that ate 400 grams of small fish that ate 5000 grams of zooplankton that ate 160000 grams of phytoplankton! If the efficiency rate was doubled (20%), however, the killer whale would only need to consume 5 grams of large fish that ate 25 grams of small fish that ate 125 grams of zooplankton that ate 625 grams of phytoplankton.

2. Describe how a biological pump works. What percentage of organic material from the euphotic zone accumulates on the sea floor?

A biological pump works by removing material fixed by phytoplankton from the euphotic zone to the sea floor. CO_2 and nutrients from the upper ocean are pumped downward to the deep sea water and sea floor sediments where they are ingested, re-egested, and respired by benthic organisms. Only about 1% of organic material from the euphotic zone accumulates on the sea floor, and only 0.1-0.2% of the phytoplankton becomes buried in the benthic sediments.

3. In class, you have looked at satellite images of ocean color. You know that most of the tropical and subtropical ocean is rather oligotrophic. Yet, there are environments in the *tropical* ocean that are an exception. Name *two* and explain which oceanic factors contribute to their higher productivity.
    a) At margins of the oceans, where there is an abundant supply of nutrients from land, a shallow thermocline where phytoplankton are close to the surface, and where macroalgae thrive on shallow continental shelf environments.
    b) In regions of equatorial upwelling, where the trade wind convergence causes upwelling that brings cold, nutrient-rich water to the surface.
    c) In coral reefs, where shallow ocean environments have a large biomass.
    d) In regions where iron-rich dust has settled on the ocean surface and caused algal blooms to occur by fertilizing them.

4. The last questions refer to primary production in the ocean.
    a) What is the group of organisms called that carry out photosynthesis in the open ocean?

    Phytoplankton

    b) What does the term "NET primary production (NPP)" refer to?

GLG/BIO 394
Oceanography Class Homework #6 –SOLUTION KEY

NPP is the difference between the Gross Primary Production (GPP) and Respiration (R). In other words, NPP = GPP – R

c) What is the depth interval called where NPP is positive?
In the euphotic zone where light penetration is 1%.

d) Name and briefly explain the depth where NPP is zero.
NPP is zero at the compensation depth for photosynthesis (~100 m deep). Below that depth the net productivity of photosynthetic organisms = 0.

e) Approximately how many grams of carbon (remember the order of magnitude that we used) are absorbed by *primary production* in the entire ocean per year?
Approximately 50 Pg C y^{-1}. This is similar to the value absorbed on land per year as well.