SIO 280 Mid-term Exam

Three questions from these ten will be on the mid-term exam. All questions are of equal value for marking. Plan the detail of your responses so that you can answer three questions in the 50 minutes allotted.

You can bring one 8.5x11" piece of paper to the exam, with writing on one side only, to aid in your answers. You must hand the sheet in with the exam.

1) You are adrift alone in a life raft after your research vessel sank in the Pacific at the western edge of the CalCOFI sampling grid. You can tell by the sun that you are drifting east, and you're hoping to reach San Diego in a week or so. In the meantime, you decide to do something useful with your time. Luckily you have several hundred feet of string, and a picnic set containing the usual cutlery, cups and plates. Describe how you would measure the vertically integrated phytoplankton biomass along your route, and the patterns you would expect to see along your transect.

2) When at sea, you often see fish and marine mammals (large animals) but you almost never see large plants. Why?

3) A spherical phytoplankter with a 2.5 µm radius takes up ammonium that has a diffusivity of 10^{-5} cm²/s. A spherical bacterium with a 0.5 µm radius takes up a large molecule with a diffusivity of 10^{-6} cm²/s. Assume that both organisms are nutrient limited. If the background concentration of both nutrients is the same, and the concentration at the cell surface is the same for both organisms, which one do you think would divide more rapidly, and why?

4) Below is a figure from a paper written by a Scripps physical oceanography student, Magdalena Carranza (she just defended her thesis a couple of months ago). Magdalena used data from profiling sensors – and sensors attached to elephant seals – in the Southern Ocean. She compared mixed layer depth (MLD) to the deep chlorophyll maximum depth (DCMD – the depth of the subsurface chlorophyll maximum). The mixed layer was estimated as the depth at which the density was a certain amount greater than at the surface (the four different density differences Δσ are stated in the figure legend); all the methods show the thickness of the surface layer of water that is
homogeneous in density (i.e., no vertical density gradient), and thus well mixed. The colors show the probability of finding a particular DCMD and MLD. Notice that there are lots of occurrences (~50% of all observations) in which the DCMD is shallower than the MLD. In other words, there is a gradient of chlorophyll in a water column that is well mixed with respect to density.

How could this happen? Why isn’t the chlorophyll completely mixed too?

Figure A.4. Two-dimensional probability density of occurrence functions between deep Chl-a-maximum depth (DCMD) and the MLD using a fine-density threshold of (a) 0.005 kg m$^{-3}$, (b) the density algorithm from Holte and Talley [2009], and density thresholds of (c) 0.03 kg m$^{-3}$ and (d) 0.125 kg m$^{-3}$. Data includes only nighttime profiles from elephant seals, EM-APEX and Argo floats characterized by having DCM.
5) Species all have traits, such as size, shape, growth rate, motility, etc. These traits all come with evolutionary advantages and disadvantages. Consider the phytoplankton trait of swimming. Some phytoplankton swim, while others do not. List and discuss two benefits and two costs of phytoplankton swimming.

6) In which environment would you expect the highest percentage of primary production to reach fish: a region with high $f$ ratio, or a region with low $f$ ratio? Explain.

7) You’d think phytoplankton would be black, wouldn’t you?

8) Jenkins (1980) integrated the oxygen utilization rate (OUR) with depth below the euphotic zone, and from that integration calculated the rate of new production. Explain his logic and assumptions in making this equivalence.

9) Uitz et al. (2006): Paragraph 45: “When the absolute contents (as mg m$^{-2}$, Figure 6b) are considered, a simple picture emerges; the increase in the chlorophyll a values along the trophic continuum (two orders of magnitude in [Chla]$_{surf}$) is essentially caused by the increase in the microplankton biomass. Meanwhile the picoplankton population appears as a rather constant background (approximately 5 mg m$^{-2}$), whereas the nanoplankton population experiences an increase (actually a tripling) from oligotrophic to eutrophic conditions.” Explain what they are saying. What ecosystem dynamics would lead to increases in microplankton (not picoplankton) being the dominant contribution to increases in chlorophyll?

10) The Mars rover found photoautotrophic life growing in an orange fluid on the surface of Mars. What wavelengths would this fluid absorb most strongly? What color do you think that phytoplankton would be living in this fluid? Why? What ratio of wavelengths would you choose (from the ones available on MODIS) to do remote sensing of these phytoplankton pigments? Why?