

OCN421 – Problem Set #3
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1. During a recent cruise to the equatorial Pacific (at 0°, 140 °W in September 1992) new production was measured, using the NO₃ uptake technique, to be 2.89 mmol N m⁻² d⁻¹ while particulate organic carbon export was measured using drifting sediment traps to be 10.0 mmol C m⁻² d⁻¹.
 - a. Were new and particulate export fluxes in balance on a carbon basis? Assume Redfield ratios hold for uptake and particulate export material.
 - b. If not, what might be the explanation?

2. Use Broecker's two-box model (e.g. see lecture chapter 10) and the concentrations listed below to answer the following questions.

Mean river and ocean concentrations in moles m⁻³.

| Constituent | C _{river} | C _{surf} | C _{deep} |
|-----------------|--------------------|-------------------------|-------------------|
| P | 0.0013 | 0.02 x 10 ⁻³ | 0.0023 |
| NO ₃ | 0.030 | 0.03 x 10 ⁻³ | 0.030 |
| DIC | 1.2 | 1.95 | 2.30 |
| Ca | 0.36 | 10.20 | 10.30 |

- a. Calculate the particulate carbon flux to the deep sea. Compare this value to the fossil fuel CO₂ production rate of 5.4 Gt yr⁻¹ (5.4 x 10¹⁵ g yr⁻¹). What fraction of the carbon in the particulate carbon flux originates from rivers?

- b. Calculate the P:N:C:Ca ratio of the particulate matter leaving the surface ocean. How does your value compare with that of Broecker and Peng (1982)? [Lecture Chapter 8, Table 8-5; P:N:C:Ca = 1:15:131:26]

- c. If surface seawater oxygen concentration is equal to the value at saturation with the atmosphere at a temperature of 0 °C and seawater salinity of 35, which is 3.5×10^{-4} moles kg^{-1} , predict the oxygen concentration of the deep ocean layer. What is the AOU? Compare the result with observations.
3. You have measured O_2 concentrations in the surface ocean over the course of a month during the summer. Average temperature and salinity were 25 °C and 35, respectively, for the period of observation. Average O_2 concentration was 240 $\mu\text{moles kg}^{-1}$. The concentration appeared to be at steady state.
- Draw a box-model for the mass balance of O_2 in the surface layer. Indicate the primary sources and sinks. Assume that vertical mixing processes were negligible during the period of your study. Be sure to include gas exchange, bubble injection and biological production in your model.
 - Calculate the air-sea gas exchange using the stagnant boundary layer model. Assume that $D_{\text{O}_2} = 1.7 \times 10^{-5} \text{ cm}^2 \text{ s}^{-1}$ and z (the stagnant boundary layer thickness) = 30 μm . The saturation concentration of O_2 for the conditions of your study is 220 $\mu\text{moles kg}^{-1}$.
 - Determine the magnitude of the biological oxygen signal, assuming that bubble input was negligible.
 - What is the equivalent carbon production in $\text{molC m}^{-2} \text{ yr}^{-1}$ based on this biological oxygen signal (assume that 1 kg ~ 1 L)? How does it compare to total primary productivity estimates in the world's oceans? New primary productivity? Which of these fluxes should your estimates agree with and why?
4. Assuming you know the value of total CO_2 and pH in surface seawater, solve for the concentration of CO_3^{2-} by two approaches.
- Draw a distribution diagram on graph paper for the carbonate species in seawater for Total $\text{CO}_2 = 2.0 \times 10^{-3} \text{ mol kg}^{-1}$. Use apparent seawater constants (e.g. K') from Chapter 12. Label the lines for H_2CO_3 , HCO_3^- , CO_3^{2-} , H^+ and OH^- . Determine from the graph the concentration of CO_3^{2-} at pH 8.0.

- b. Derive an algebraic equation to solve for the concentration of CO_3^{2-} from knowing the Total CO_2 and pH. Solve the concentration of CO_3^{2-} for Total $\text{CO}_2 = 2.0 \times 10^{-3} \text{ mol kg}^{-1}$ and $\text{pH} = 8.0$.