

Problem Set #5
Marine Chemistry 12.742

Problem 1:

Figure 1 is a time-series of dissolved Fe concentration from the HOT station 100 km north of Honolulu. Data comes from Boyle et al. [in press]. Samples are collected at a depth 35 m, which lies in the mixed layer

- A. What process(es) could be responsible for this temporal variation.
- B. The annual averaged dissolved concentration of Fe in the 75 m mixed layer at HOT is 0.4 nmol/kg water. The annual average atmospheric aerosol flux of Fe to this region is estimated be 10 mg Fe per m² per year. Using this flux value, what is the residence of Fe in the mixed layer?
- C. Many studies have concluded that only 1% of the aerosol Fe reaching the ocean is dissolved in seawater. If that is the case, what is the residence time of dissolved Fe in the mixed layer? Is this residence time estimate of Fe consistent with the time-series data in figure 1? If not, how can you reconcile residence time values based on atmospheric fluxes with the variability of dissolved Fe in the mixed layer (fig. 1)?

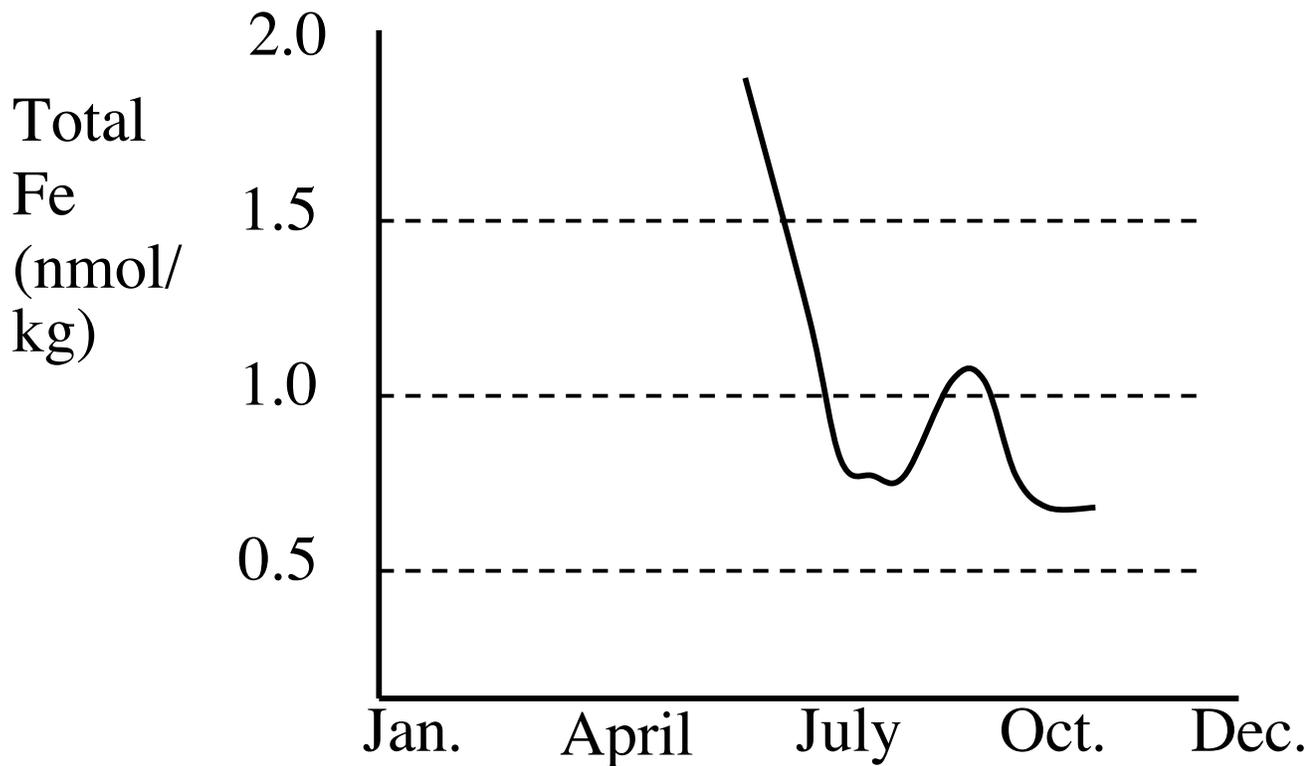
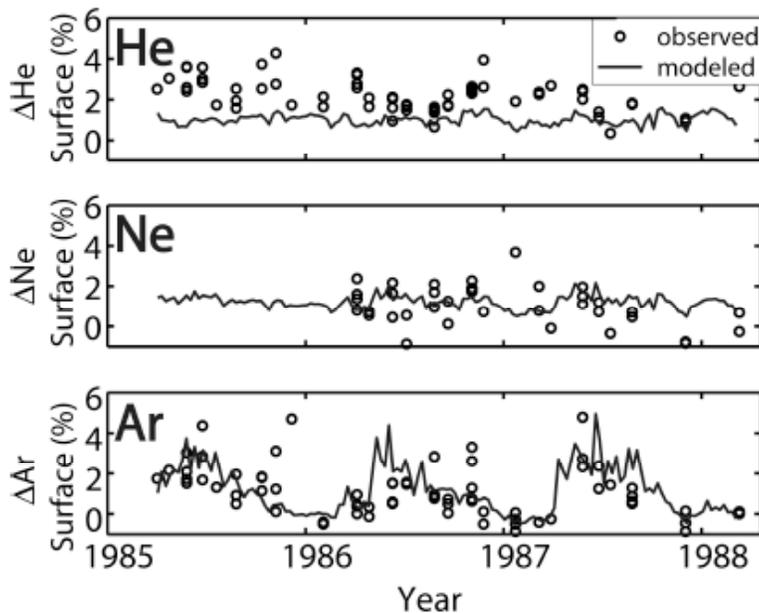


Fig. 1

Problem 2:

- Estimate the “stagnant film” thickness and “surface renewal” time-scale for an O_2 piston velocity of 2.5 m/d. Use a diffusivity of $1.45 \times 10^{-9} \text{ m}^2 \text{ s}^{-1}$ and a Sc number of 455. If the equivalent Sc for thermal diffusivity is ~ 8 , what does that say about the relative size of the thermal versus dissolved gas diffusive boundary layer?
- Calculate the approximate gas exchange time-scale for dissolved oxygen in the ocean surface mixed layer for conditions above for a mixed layer of 75m depth.
- Estimate the gas exchange timescales for CO_2 and $^{14}CO_2$ under the same physical conditions given:
 - Schmidt number for $O_2 = 455$ and for $CO_2 = 1922$;
 - $H_2CO_3^* = 10 \text{ umol/kg}$, $HCO_3^- = 1800 \text{ umol/kg}$, $CO_3^{2-} = 200 \text{ umol/kg}$;
 - Revelle factor (fractional change in pCO_2 for a fractional change in total dissolved inorganic carbon: $R = \frac{\partial pCO_2}{pCO_2} \frac{DIC}{\partial DIC} = 10$)
- Consider the time-series of He and Ar gas saturations in the mixed layer given below for Bermuda. Given what you know about gas exchange, mixed layer depth and temperature, what do you think could explain the:
 - Supersaturation of He throughout the year
 - Large seasonal cycle in Ar supersaturation



e)

Problem 3:

Use BATS mixed layer data from the figure below to answer the following questions (estimate values where appropriate):

- Describe the factors that could govern the observed seasonality in chlorophyll and primary production.
- Calculate a winter time euphotic depth, compensation depth and critical depth given:
 - $k_{par} = 0.03 + 0.04 \cdot chl$ (1/m)
 - surface PAR irradiance $17.5 \text{ mol photon/m}^2/\text{d}$
 - compensation irradiance $1.3 \text{ mol photon/m}^2/\text{d}$Are these values consistent with your discussion on light effects in a)?

BATS - Mixed Layer Averages

