Examination GEO4-1440, Monday April 16, 2012

Total number of points: 100
Questions 1-6 and 7-12 should be handed in on separate sheets to facilitate corrections.
Please answer concisely.

1. *12 points (3,3,3,3)*
Water samples were taken in a stratified lake at different depths to estimate the role of
ammonia oxidizing archaea (AOA) in the nitrogen cycle of the system.
a) Specify which methodological approach would you follow to estimate the diversity of
    this microbial group. Give an example of which gene marker would you use.
b) Mention one technique to quantify the abundance of AOA. Which molecule would you
    target?
c) Which molecule would you target to estimate activity?
d) Put the following molecules in order of less to more resistant to diagenesis
    (degradation): lipids, RNA, DNA

2. *10 points (5,5)*
The ocean accounts at present for about 30% of the anthropogenic carbon uptake.
a) What are the main processes involved?
b) Would you expect the ocean to become more or less efficient in absorbing
    anthropogenic carbon dioxide. Which processes would stimulate and which would
    diminish the potential for carbon dioxide uptake.

3. *8 points (4,4)*
Nitrogen cycling is sometimes quantified using the N* concept.
a) What is the rationale underlying the N* concept.
b) What are the pitfalls and limitations inherent to the use of this concept.

4. *8 points (4,4)*
One of the most traditional tools in oceanography is the Secchi disk, a white circular disk
mounted on a line. Scientists use the Secchi disk to quantify the depth at which the disk is no
longer visible since this gives a measure of the transparency of the water.
a) Which factors govern the transparency of marine waters?
b) Historical records of changing Secchi disk depth can provide useful information on
   ecosystem changes. Why?.

5. *6 points*
Spring blooms are major phenomena in mid and high-latitude marine systems. Please
explain why spring blooms occur?

6. *12 points (2,2,2,6)*
The figure below shows sulfate reduction and methane oxidation rates in a sediment core
from a Danish fjord. Explain the depth distribution of sulfate reduction rates.
a) Why are sulfate reduction rates low in the top few cm?
b) Why do sulfate reduction rates decline with depth?
c) Why do sulfate reduction rates show a subsurface maximum at depth
d) What is the ultimate fate of the sulfide produced in sediments.

nmol cm^{-3}day^{-1}

Station B

Depth [cm]

Sulfate reduction rate

Methane oxidaton rate
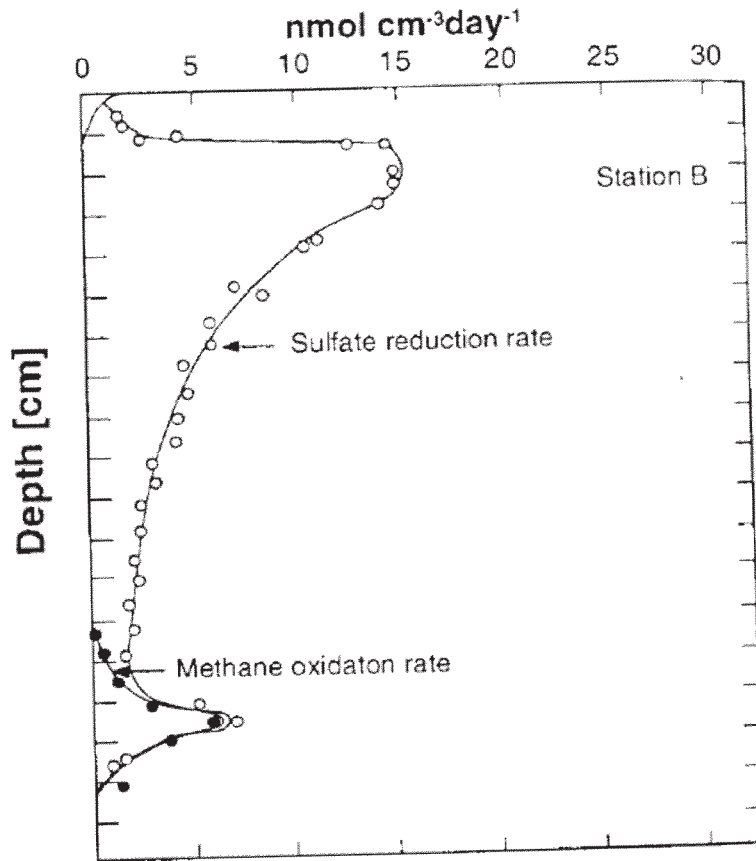
7. 6 points (2,4)
Many groundwater contaminants can be degraded by microorganisms.
a) What is the main reason for the occurrence of different redox zones in contaminated aquifers with biodegradation?
b) What is the difference between engineered in situ remediation and natural attenuation?

8. 8 points (4,4)
Stable isotope signatures can be used to determine if biodegradation takes place at a site:
c) Describe the basic principles of stable isotope fractionation and how it can be used to detect biodegradation qualitatively.
d) How can the Rayleigh fractionation model be used to quantify biodegradation using stable isotope signatures?

9. 12 points (4,1,3,1,3)
Consider a batch experiment where microorganisms are oxidizing DOC to gain the energy needed for their growth. The system is closed without any exchange with its surrounding.
a) What is the growth rate of the microorganisms in case DOC is the only rate limiting species and no other processes limit the growth of the microorganisms? Give the equation.
b) Draw schematically the concentration plots for DOC and microbial biomass vs. time.
c) Give three examples for processes besides DOC limitation, which can limit the buildup of microbial biomass in subsurface environments.
Consider oxygen and sulfate being the only terminal electron acceptors present in the system.

d) Draw schematically the concentration plots you would expect for oxygen and sulfate vs. time.
e) Give an example on how such as system can be described by microbial growth kinetics.

10. *6 points*
Bacteria are involved in the turnover of nitrogen species in soils. Describe which bacterial functions are relevant for nitrogen cycling in soils.

11. *6 points (4,2)*
a) Describe the meaning of "bioavailability" (in the context of microbial processes) and why it needs to be considered in terrestrial systems (soil, groundwater).
b) How can fungi change the bioavailability of a compound?

12. *6 points (1,1,2,2)*
a) When did the first microorganisms appear in Earth's history?
b) What was a prerequisite for the formation of the first cellular life?
c) Living organisms can be grouped into three domains: Bacteria, Archea and Eukarya. Which domains include microorganisms and which include higher organisms?
d) In which habitats can you find
Hypothermophile microorganisms?
Acidophile microorganisms?