AQUALEX MULTIMEDIA CONSORTIUM

E-AQUALEX Aquatic Sciences e-learning Toolset

The Marine Environment - Week 4

Section 1 Part 4 (Oxygen) and Part 5 (Substrate)

Oxygen

We know from chemistry that an atom of oxygen and two atoms of hydrogen form a molecule of water. Consequently, oxygen forms part of the water at all depths in all areas of the world. However, oxygen bound in this manner cannot be used for the respiration of marine organisms. What they need is molecular oxygen (O^2) which is dissolved in sea water, as well as other gases, in much smaller quantities.

Dissolved oxygen concentration is affected by physical, chemical and biological processes. Factors which cause an increase in dissolved oxygen concentration are photosynthesis, diffusion from the sea surface, and mainly the action of the wind and the currents which by causing surface water turbulence*,* saturate the surface layers with oxygen. Reduction of dissolved oxygen concentration is caused by the respiration of marine organisms and by the oxidation of organic substances either by simple chemical reactions or by bacterial activity. High temperatures and high salinity values lead to a reduction in oxygen solubility.
Nearly all living organisms need oxygen in order to carry out their biological processes.

However, the quantity of oxygen demanded differs according to species, mode of life, sex, age as well as environmental factors such as temperature, salinity and the presence of various types of pollutants. Thus, both the increase in and decrease of oxygen in the water have different effects on different species. For instance, animals are much more sensitive than plants are to anoxia; in general high mobility organisms need much more oxygen, since they can migrate away from anoxic areas, while there are organisms which have developed the ability to use glycogen as an alternative source of oxygen over a relatively short time interval. And others are able to use the sulphur from hydrogen sulphide that occurs when all oxygen is used up by the bacteria. Anoxic or hypoxic areas are an increasing problem in coastal waters where increasing eutrophication leads to an increased oxygen demand on the sea bottom and leads to fauna kills of considerable extent. Also in other areas of high organic anthropogenic input such as sewage outlets, paper mills and fish farms there may be locally restricted areas of bottom anoxy devoid of any macroscopic fauna.

Part 5

Substrate

Substrate is an element determining the sort of marine organisms encountered in an area. In general there are two types of substrate.

5.1

Hard substrates

Hard substrates (rocks, boulders, pebbles, hard surfaces) which consists of rocky surfaces of the coast and boulders and pebbles in the coastal fringe. Man-made structures like harbour constructions or off - shore constructions are called secondary hard substrates, they also include shipwrecks and floating objects (ships, boats, buoys etc). In some cases hard substrate can be created by plants or animals with the capacity to accumulate Calcium carbonate ($CaCO^3$). This kind of substrate is called biogenic and is a very good example of the way that organisms can affect the environment by changing some of its major features.

5.2.

Soft substrates

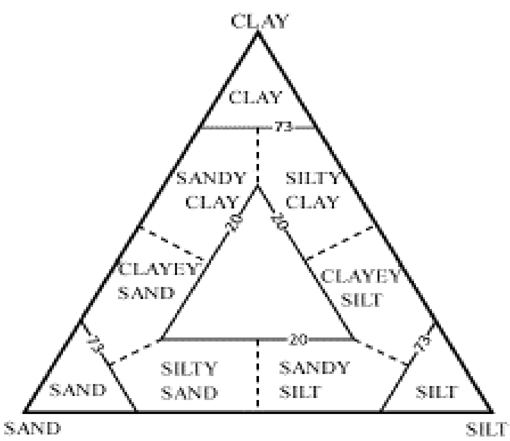
Soft substrates: sediments consisting of grains of different size and mainly categorised as sand, silt or clay, according to size.

	Grade limits		
Name		mm	cm
Boudler		Above 256	
Cobble		256 - 64	
Pebble		64 - 4	
Granule		4 - 2	
Very coarse sand	Sand	2 - 1	2000 - 1000
Course sand	Sand	1 - 0.5	1000 - 500
Medium sand	Sand	0.5 - 0.25	500 - 250
Fine sand	Sand	0.25 - 0.125	250 - 125
Very fine sand	Sand	0.125 - 0.0625	125 - 65
Silt		0.0625 - 0.00006	62 - 0.06
Clay		Below 0.00006	< 0.06

Figure 9. Wentworth grade classification.

Sediments are classified according to the size and size distribution of their grains in the categories described in **Figure 9** after the Wentworth classification Scheme.

Most sediments do not fall into a single category but are characterized by a mixture of grains of different size. In this case they are represented either descriptively, using the names of the dominant parts (silty sand etc.) or by means of mathematical indices such as mean grain size.



a) Sand - Silt - Clay Ratios

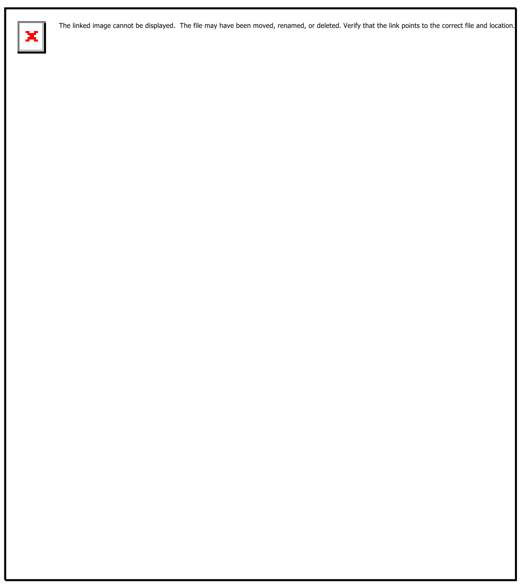


Figure 10. a & b.

Another way to present grain size mixtures is the use of triangular diagrams (from **HOLME & MCINTYRE 1984 p.58).**

Sediment composition is closely related to water movement. In general the higher the water velocities the larger the grain diameter it can remove. The underlying processes are called erosion and deposition (hot text) That is why in exposed beaches it is mainly sand and pebbles that are found, while in more protected, less exposed beaches there are varying amounts of mud as well. Below the zone affected by waves there are usually high percentages of silt and clay, unless there are strong water currents.

5.3

Redox potential

Another important parameter characterizing marine sediments is the redox regime: this is related to the concentration of oxygen dissolved in the water occupying the space between the grains (interstitial water). This regime is described by the redox potential (Eh) measured in mV. In general oxidizing conditions (high Eh values up to +400 mV) mean high oxygen concentration while reduced conditions (low Eh down to -200 mV) reveal a lack of oxygen. Since most animal species need oxygen, it follows that low Eh sediments are poor in fauna.

Redox potential is affected by the following parameters:

a) sediment grain size

The larger their diameter the better the water circulation in the sediment and consequently the easier the oxygenation. Thus fine material (silt, clay) should be expected to show lower Eh values than sandy sediments.

b) organic content

Decomposition of organic content by bacteria leads to fast oxygen consumption. As a result sediments with high organic content usually have extremely low Eh values.

c) oxygen concentration in seawater above the sediment.

If the oxygen content of the sea water is low then its ability to supply oxygen to the interstitial water is limited, hence the Eh values cannot be other than low.

Figure 11 shows the change of redox potential in relation to depth from the sediment surface in two sediment types. In both cases there is a brown layer where oxidising conditions prevail, deeper down there is a black layer where reduced conditions prevail and in-between the two there is a thin gray layer where the redox potential changes rapidly in a rather small distance.

This gray layer is called “Redox Potential Discontinuity” layer (RPD). Here it is easy to see that in fine sand sediment the RPD is closer to the surface than in coarse sand, because the penetration of oxygenated water is obviously more difficult in fine grain sediments.

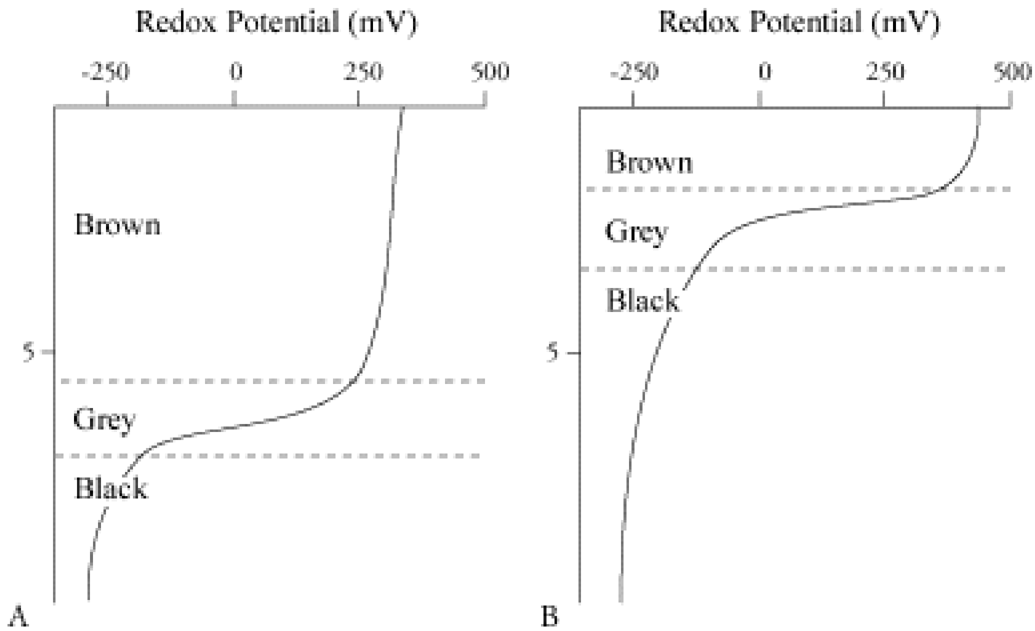


Figure 11. Typical redox potential profiles for two intertidal sediments: *A* medium sand, *B* fine sand