WEEK 3

Section 1 Part 2 Water movements

3. Water movements (Waves, tides, currents)

3.1 Waves

Waves are caused by the action of the wind and depend on its velocity, duration and the distance over which the wind blows. The distance between two successive wave crests is called wave length (L). At depths less than L/2 from the sea surface, waves cause orbital movements which mix the water and suspend sedimentary particles, while below this depth wave influence becomes negligible (**Figure 6**).

As the wave approaches the coast, it "breaks" and releases its kinetic energy through the formation of smaller waves and turbulent water masses which wash on to the beach. The energy of these waves has a major impact on both the formation, the size spectrum and the distribution of the seashore substrate and the organisms living there.

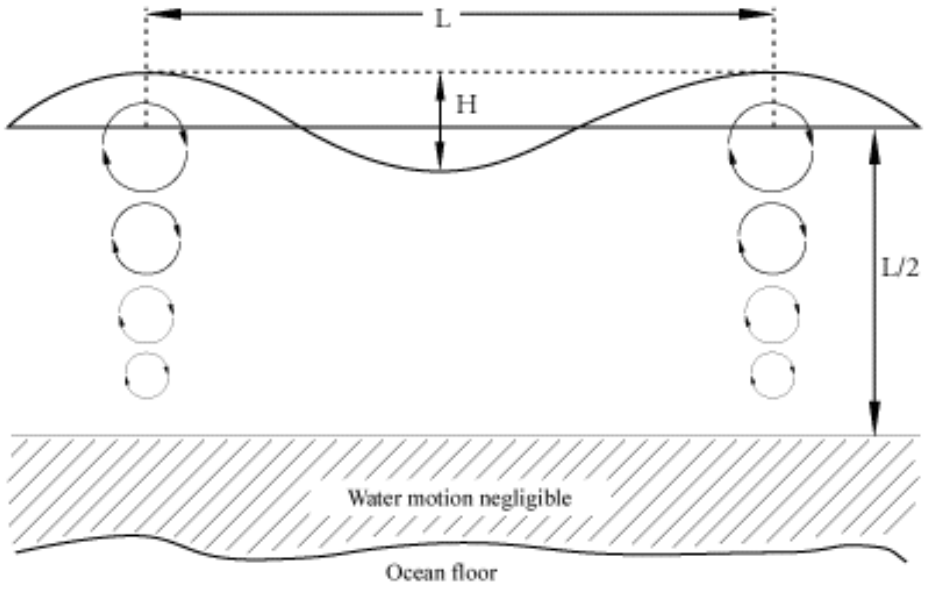

Figure 6. Dimensions of ocean floor.

The organisms living there have developed specific adaptations, like holdfasts, special flat shapes etc. **(Figure 7**) in order to cope with these high energy conditions.
Wave impact on the shore differs according to the coast morphology, the substrate texture and the frequency and direction of the prevailing winds of the area.

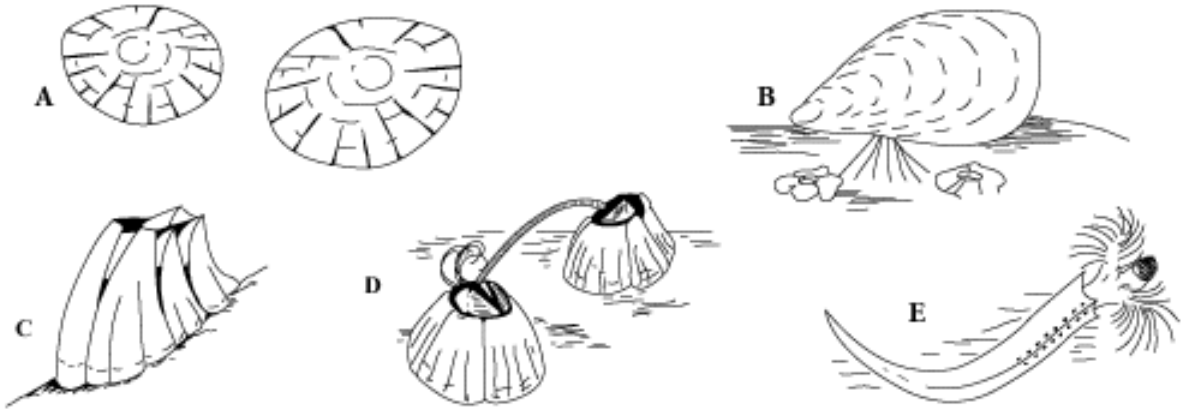

Figure 7. **A. Patella** :flat shape and strong muscles in order to stay attached to the substrate;
B Mytilus: firmlyattached to the substrate by means of its byssus;
C Barnacles: firmly attached to the substrate;
D Barnacles: mating without changing position;
E Serpulid worms: living in calcareous tubes stuck on the hard substrate.

3.2 Tides

Tides are caused by the combined action of the earth, moon and sun gravity forces. In **Figure 8** the extreme water levels occurring during high and low water are presented. When earth, sun and moon are all in one line a spring tide occurs with maximal increase and decrease alternately of water level. When they form a right angle, neap tides occur. The period of spring tides is two weeks and low-high water approximately one day (24 hours and 50 min.).

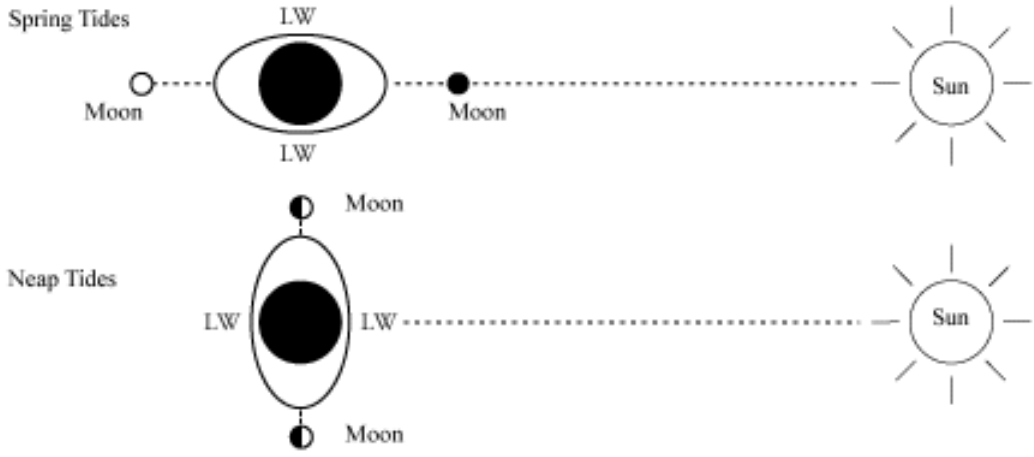

Figure 8. Action of tidal forces at different alignments of the sun and the moon.

3.2.1

The influence of tides on the coastal ecosystem is quite important. During the elevation or fall of the water level horizontal movements of water masses (tidal currents) occur which are more pronounced when the coast inclination is small. This movement results in water renewal which increases oxygen levels and transports not only sediments and suspended material but also plankton and pelagic larvae. It is a process is of great importance, especially for areas protected from wave action (**closed gulfs, fjords** etc.) where tide is the main factor in water renewal.

3.2.2 Organismic adaptations

Organisms living in coasts of intense tidal variation are obliged to adopt a mode of living to make sure that they survive during low water; this is the time when they have to face and overcome the problems of respiration, desiccation and predation from large predators (i.e. marine birds). That is why they prefer to live in the sediment rather than on its surface. There they may also develop exoskeletons or hard shells (chitinous or calcareous) in order to protect themselves from predation, or hermetically closing shells or mucous covers that retain water. They may also develop the ability to use atmospheric oxygen, using anaerobic metabolic pathways. They may also minimize their energy requirements (and consequently their oxygen demand) during emersion. There are many other adaptations which may occur at the morphological, physiological and behavioural level.

3.3 Water currents

3.3.1

The term “water currents” is used to describe water movements of different kinds caused by different events.

a) the movement of the earth which causes the development of the Coriolis effect
http://www.eoascientific.com/interactive/the_coriolis_effect/the_coriolis_effect.html

b) the combined effect of wave action and barometric pressure and

c) water density differences between tropical areas and polar areas.

Currents play an important role not only through oxygen, nutrients and other elementary substances of sea water transportation but through the dispersion of organisms (especially low mobility ones) as well.

3.3.2

Upwelling

The upwelling phenomenon is known from western coasts of the continents and also on a local scale where cold water masses rich in nutrients are slowly rising to the surface. In this way the upper water masses are enriched in nutrients. Upwelling is usually encountered on the western coasts of large continental areas (due to Coriolis forces and Ekman transport (http://www.britannica.com/search?query=Ekman+transport) and ensures extremely high productivity (Sardine fishery at the Peruvian coast). Disturbances of this phenomenon due to large scale climatic variability which occur mainly around Christmas time are called the „El Nino“- phenomenon when the whole current system is shifted and warm water covers the cold and productive deep water. In this year’s extreme water precipitation in coastal regions are combined with drastic changes in the biotic environment leading to massive crops of some and extreme kills of other species.
http://www.pmel.noaa.gov/tao/elnino/el-nino-story.html

Apart from well-known major currents like the Humbold current or the Labrador Current with a more or less permanent direction, there are many others which are smaller in scale but of great local importance. These may show differences in intensity and/or direction according to the season (Monsoon) and/or local meteorological conditions.