

## SEA MOTIONS

The ocean said to be constantly in motion and their motions have been an immense advantage to marine environment. Such motions are known to enhance the mixing and diffusion processes. Secondly, they are known to minimize salinity and temperature variation. Thirdly they serve to enhance the dispersal, swimming and floating of organisms and their reproductive products. Fourthly, the oceanic circulation carries away toxic wastes. They recycle and replenish food nutrients, dissolved gases and essential elements.

The primary driving forces behind these oceanic circulations include:

- i. Heat from the sun
- ii. Additional contributions from gravitational attractions or the moon and sun.

Motions of the ocean include waves, current, vertical water movements, and tides.

### **Waves:**

Wave is a disturbance propagated in a medium in such a manner that at any point in time in the medium the displacement is a function of time while at any instant, the displacement of a point is a function of position of the point. Different solar heating of the various regions of the earth's surface and the atmosphere generate wind. In turn, the wind blows across the seas surface to produce waves. The size of these waves produced depends on:

- i. Velocity of wind
- ii. Direction of the wind
- iii. The distance of the area over which the wind blows which is known as fetch
- iv. Duration of wind.

Waves are characterized by (i). the period,  $T$ . - this is the time it takes the wave formed to move through one wavelength. (ii) wave length,  $l$ , is the distance between two successive wave crests measured perpendicular to the wave crest. (iii) wave height,  $H$ , - the distance between opposite wave crests and wave troughs measured perpendicular to both crests and troughs.

The depth to which waves produce a noticeable motion is about half its wavelength. Wavelength seldom exceeds 100m in any ocean. The depth of effective mixing by “wind drive waves” is generally not greater than 50m. The period, J, and velocity of the wave formed are closely related to the wavelength. The relationship between the three can be represented as

$$L = CT$$

L= wavelength

C= velocity

T = period.

This formula differs in deep water because of velocity in deep water is represented by

$$C = \sqrt{gL / 2\pi} \quad g = \text{force of gravity}$$

While in shallow water it is:

$$C = \sqrt{\frac{gL}{2\pi} \tan \frac{2\pi d}{L}} \quad d = \text{depth of water}$$

### Types of wave:

- a. **Ripples** or capillary waves – there are waves with wavelength less than 6.28cm, generally caused by winds.
- b. **Swells:** this happens when a wave attenuates there the wave out of generating area into calmer waters. It is then modified to become swell. Swells are more uniform and larger crested due to reduced height. They are also caused by wind/
- c. **Solitary waves:** there are waves that move independently of each other. These are found in shallow waters where the velocity of the waves depends only on the depth. There are also caused by wind. Each solitary wave consists of crest separated from its neighbours by flat water in which the water particles are at rest.
- d. **Long waves** there are waves in the ocean whose lengths are considerably longer. There are different types of longer. There are different types of long wave.
  - a. **Surf beats:** these are long waves with period which have been recorded to range from 1-10minutes. These are caused by gravity and are sometimes menace in the harbour. They are forced waves that can be modified into a free-wave close to the shore.

- b. Microseism:** there are long waves associated with ocean storm. The main cause of this type of wave is the interference between two wave trains of equal period travelling in opposite directions. Sometimes the reflection from a steep coast can result in interference between waves of the same period. Microseism travels much more and rapidly in the earth's crust than the waves on the ocean surface so that they frequently arrive at the coast sometimes before the storm wave will reach the coast. This, thus, gives a warning of approaching damaging waves or storms or storm dwells.
- c. Tsunami:** this is seismic wave. It is a long wave caused by seismic activity (earthquake). It is usually generated by a submarine earthquake know as "Tsunami" (by Japanese). Any sudden movement in the earth crust under the sea will affect the water above resulting in "Tsunami". Waves produced by earth quakes have enormous lengths of about 160km though their height in the open sea may only be between 30-60mm. They are so long that their velocity depends only on water depth. They are normally not felt by ship in the open seas but as they approach close to the shore where water depth decreases, the speed of the wave will slow down and the height increases. Long wave of this type can travel an immense distance with out substantial loss of energy. There have been reports of devastating effects of "Tsunami" in Japan, Hawaii, and Alaska.
- d. Meteorological surges:** they are long waves generated by meteorological condition. Very sudden change in wind direction is important in the formation of surges. Exceptional strong wind drives a considerable amount of water causing surge.
- Surges result in a rise in sea water level. These may coincide with high or low water tides and may increase water level beyond predictable values. They are particularly dangerous when they coincide with high tide. Surges are very prominent in the Northern seas. They are two major types:
- i. External surges: these are generated outside the sea and move as free waves anticlockwise round the sea.
  - ii. Internal surges: which originate inside the sea.

## Tides:

These are periodic rise and fall of the sea surface usually unnoticed in the open sea but only against coast lines. They are known to have long period waves and are usually caused by gravitational attraction of the earth, moon and sun from one another. Tides are characterized by

- i. **High tide:** this is the max elevation of the tide due to rise in sea water level.
- ii. **Low tide:** the minimum level due to fall in sea water level following high tide. Too low or too low tides occur every day on most coast lines.
- iii. **Tidal range:** is the vertical difference between high and low tides. It can vary less than 1m to over 15m depending on the coast lines.
- iv. **Intertidal zone:** this is the zone of the range of high and low tides on the coast lines. It is usually covered at high tide and exposed at low tide. It is a zone of unique marine life because here, the sea, land and air all play important roles in establishing the complex physical conditions in which all the intertidal plants and animals must adapt to. Tide seas are important in influencing the
  - i. The movement of materials
  - ii. Morphology of the sea floor.
  - iii. Waves and shipping activities at the coast.

## Tides producing forces:

Ocean tides are the consequences of gravitational attraction of the moon and sun and the ocean of the earth. From the Newton's law of gravitational, the gravitational force of attraction between two bodies is directly proportional to the product of their masses and inversely proportion to the square of distance between the bodies.

The mass of the sun is about 27million times greater than that of the moon. Yet, the moon exerts twice as much influence on the earth's tide. This is because of the earth-moon distance which is only 1/400 of the earth-sun distance i.e it is nearer to the earth and thus compensates for the moon small size.

The moon completes an orbit around the earth each lunar month (28days) and in reality it is 27 days. To maintain this orbit, the gravitational force between the earth and the moon must exactly balance the centrifugal force holding the bodies apart. On earth, the centrifugal force everywhere is equal in direction and magnitude and is directly opposite the gravitational force.

Linear tides are produced by the attraction of moon while solar tides (1/2 as high as lunar) are produced by gravitational attraction of sun.

Assuming hypothetically that the earth is completely covered by water, two bulges of waters (temporary increase in volume) will normally pile up; one on the side facing the moon and other on the opposite side of the globe.

Each day, as the earth rotates under its tidal bulges, a point on the surface experiences high tide when under the tidal bulges and low tides when at right angle to the bulges. As the earth makes a complete rotation every 24hours on the earth surface, it first experiences (a) high tide (b) low tide (c) high tide (d) low and finally (e) high tide.

Similarly the sun-earth system also generates tide producing forces that yield solar tides about 1/2 as that of the lunar tides. The solar tide is expressed only as a variation on the basic lunar tide pattern rather than as individual sets of tides.

### **Types of oceanic tides**

- i. Semi diurnal tide: in this tide, there are two high tides similar to each other and two low tides similar to each other. The main characteristic of east coast of USA.
- ii. Daily (Diurnal) tide: here there is only one low and one high tide each day.
- iii. Mixed semi-diurnal: there are two high tides and two low tides each day but they are different from each other.

Tidal conditions of any day of a selected coast lines can be predicted. This is because the movements of the bodies which bring about tides are regular and well known enabling the tide to be predicted with accuracy, therefore the periodic nature of tides are easily observed and recorded. The meteorological condition can, however, bring about some differences in the predicted and actual tides.

### **Currents:**

These are non-periodic water movement generated by external forces. These forces include:

- i. Friction exerted by wind.
- ii. Horizontal density variation
- iii. Changes in atmospheric pressure.

Usually 1 & 3 cause major currents. Currents in the surface layers of ocean are usually caused by wind stress, while the main cause of deep water movements is caused by density variation.

Surfaces currents: these are large scale horizontal transports of surface water occurring in different regions of the world where wind velocity and direction are slowed down over the ocean. This slow down velocity that flows from the equatorial region to the polar region are called the WARM CURRENTS because they have a high surface temperature. Those that flow from polar to equator are known as the COLD CURRENTS because they have lower surface temperature.

The direction of flow of surface current is influenced mainly by planetary winds. There are three major planetary winds:

- i. Trade wind: between the equator and the tropics e.g NE trade wind which causes the north equatorial current. SE trade wind which causes the subequatorial current.
- ii. WESTERLIES: there usually blow in the temperate region and is responsible for the N. Westerly of the N. hemisphere.
- iii. Polar easterlies: they occur at the very high latitude and usually blow from east to west. They include the antarctic sub-polar current and the arctic current in the N. hemisphere.

Generally, currents move clockwise in the N. hemisphere, and anticlockwise in the S. hemisphere.

### **Types of current:**

- i. **Geostrophic currents:** they are frictionless currents which flow horizontally without change in velocity. Gravity is the only external force that causes geostrophic current.

**ii. Inertial currents:** there are due to sudden changes in the forces that cause currents.

They result from a lack of balance between the pressure gradients, friction, and the resultant geostrophic acceleration.

**iii. Wind drift currents:** there are the current that do not flow in the direction of wind due to the friction between the wind and the sea surface as well as friction within the water which results to what is known as “Ekman’s” spiral. This shows that as the wind blow over the surface of the water the current gradually changes further right of the wind direction, and hence become slower as the depth increases. This change with depths is referred to as **CORIOLIS** effect. This reduces momentum with depth. The deflection of current to the right in the NH and to the left in the SH, is the most important feature of wind drifting current.

### **Vertical water movements:**

These are produced by sink and upwelling processes. The processes breakdown the vertical stratifications by the thermocline. Seawater sinks when its density increases, and the processes which result in increase density occur, strictly at the water surface.

**“UPWELLING”**- This is the massive rising of water from the deep bottom to the surface. Whatever the cause, upwelling processes bring deeper nutrient, rich waters to the surface layers and therefore redistribute the nutrient and increase primary productivity.

Wind and tides wave create turbulence in the near surface-water and these will mix deeper nutrient water upward. Mixing is mostly effective over the continental shelf where the shallow bottom prevents the escape of nutrients into deeper waters.

In sub-tropical latitudes of most oceans, the strong permanent thermocline near the base of the photic zone inhibits upwelling, hence, the regions have very low rate of primary productivity. Thermocline in the temperate waters is seasonal. In winter, the surface water cools (becomes denser), sinks and the thermocline disappears and upwelling occurs enriching the surface layers with nutrients. As temperature increases in the spring, the thermocline is established which becomes well developed in summer like the permanent thermocline in tropical waters. This prevents upwelling until autumn and winter when the temperature is now lowered, the thermocline weakens and disappears giving way to upwelling again.

### **Types of upwelling:**

- i. Coastal upwelling:** this is produced by winds blowing surface water away from coastline. The surface water is now replaced by deeper water rising to the surface. There are four major coastal upwelling areas, these include: California, Peru, Canary, Benguela.
- ii. Central Pacific upwelling:** it occurs in the central Pacific Ocean and limited to this area. Here, the equatorial current flows westward and the Coriolis forces cause a slight displacement of the current to the right in the NH. The resultant divergence of the water away from the equator, creates an upwelling of deep waters to replace the surface water that moved away. This area of upwelling is the basis for an important Japanese Tuna fishery.
- iii. Antarctic upwelling:** major upwelling areas occur around the Antarctic continent. In this region, the water that sank surfaces with accumulated nutrients and provides extraordinary fertility of the Antarctic seas. All Antarctic life forms depend on the marine food chain supported by this massive upwelling.