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OCEANOGRAPHY

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BOTTOM TOPOGRAPHY OF THE OCEANS

Ocean basins have a great deal of features that match those on the surface (i.e. continents) such as, volcanoes, deep canyons, rift valleys, and large submarine plateaus.

The study of sea floor by echo method of sound waves reveals that the sea floor is not a flat area. It consists of mountains, plateaus, plains and trenches etc. Some major submarine features are described below.

a) Continental Shelf

The portion of the land which is submerged under sea water constitutes continental shelf. The continental shelf is shallow and its depth is not more than 200 metres. Its slope from land to the sea is about 2 metres per km. The average width is 70-75 km, though it varies from a few metres to hundreds of kms. In all about 7.5 percent of total area of the oceans is covered by the continental shelves. The continental shelves may be of different types e.g. Glaciated shelves (sea near New England); Broad river shelves (yellow sea and the gulf of Siam) and coral shelves (those of Eastern Australia).

The shelves are of great use to man because:

1. Marine food comes almost entirely from them.
2. About 20 percent of oil and gas of the world is extracted from them.
3. They are large stores of sand and gravel.
4. They are the sites of productive fishing grounds.

b) Continental Slope

It is an area of steep slope extending just after the continental shelf up to a considerable depth from where a gentle sea plain takes its form. The extent of the slope area is usually between 200-2000 m. But sometimes it may extend to 3660 metres from the mean sea level. The continental slope along many coasts of the world is followed by deep canyon like trenches terminating as fan shaped deposits at the base. Continental slope covers 8.5 percent of the total ocean area.

There are five types of slopes:

(i) Fairly steep with the surface dissected by canyons

(ii) Gentle slopes with elongated hills and basins

(iii) Faulted slopes

(iv) Slopes with terraces

(v) Slopes with sea mounts

c) Continental Rise

The gently sloping surface at the base of the continental slope is called continental rise. It may extend to hundreds of km into the deep-ocean basin. It consists of a thick accumulation of sediment that move downslope from the continental shelf to the deep-ocean floor. Turbidity currents deliver these sediments to the base of the continental slope, and when these muddy currents emerge from the mouth of a canyon onto the flat ocean floor, they drop their load in a form of deep-sea fan.

Continental Shelf	Continental Slope:
(i) It joins shore line with continental slope.	(i) It joins continental shelf with abyssal plain.
(ii) Its slope is very gentle i.e. about 2 metres per km.	(ii) Its slope is very steep. The average gradient is about 4º.
(iii) It is a shallow water area. Its depth is less than 200 metres.	(iii) Its depth varies from 200 to 2000 metres.

(iv) There are few canyons or deeps in the continental shelf.	(iv) Deep canyons are found on the continental slope.
(v) They have large stores of sand and gravel.	(v) Very few land deposits are found on it.
(vi) They are of great use to man particularly for fishing.	(vi) They are not of much use to man.

d) Deep Ocean Basins

It is the portion of sea floor that lies between the continental margin and the oceanic ridge system.

It contains deep-ocean trenches, abyssal plains, and broad volcanic peaks called seamounts.

I. Deep-Ocean Trenches:

These are long, narrow features that form the deepest parts of the ocean. Most trenches are located in the Pacific Ocean. They may reach 10,000 m deep (Mariana trench is 11,000 m below sea level).

They are the sites where lithospheric plates plunge back into the mantle, and are usually associated with volcanic activity.

II. Abyssal Plains:

These are the most level places on Earth. The abyssal plains may have less than 3 m of relief over a distance that may exceed 1300 km. Scientists determined that abyssal plains low relief is due to the fact that thick accumulations of sediment, transported by turbidity currents, have buried rugged ocean floor. Abyssal plains are more extensive in the Atlantic Ocean than in the Pacific. That is because the Atlantic Ocean has fewer trenches to trap sediments carried down the continental slope.

III. Seamounts:

It is an isolated volcanic peak that rises at least 1000 m (3300 ft) above the deep-ocean floor. They are more extensive in the Pacific, where subduction zones are common. These undersea volcanoes form near oceanic ridges (regions of seafloor spreading). Some of these volcanoes may emerge as an island. Erosion by running water and wave action may erode these features to sea level. Over a long time, the islands gradually sink.

e) Submarine Canyons

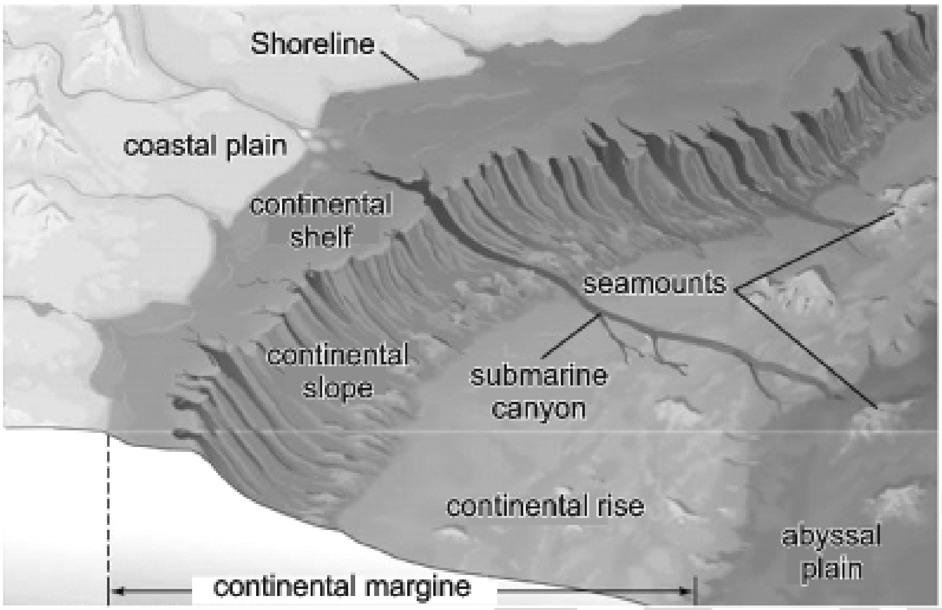
These are depressions with walls of steep slopes and have a V shape. They exist on the continental slopes and the shelves. They are found to have a length of 16 km at the maximum and have a dendritic pattern. The canyons are found to be close to river mouths such as those of the Congo, the Sindh, the Hudson, the Delaware, the Columbia, etc. The depth varies from 1,800 m. to 2,800 m. Coarse deposits are found in the canyons.

Submarine Trench	Submarine Canyon
(i) It is a long, narrow and steep sided depression on the ocean bottom.	(i) It is a deep gorge on the continental slope.
(ii) Their depth varies from 7000 to 9000 metres.	(ii) Their depth varies from 1800 to 2800 metres.
(iii) They are almost empty of sediments.	(iii) Coarse deposits are found in the canyons.
(iv) They are attributed to the endogenetic forces which have produced mountains.	(iv) They are found near river mouths and may have been the result of erosion.

f) Bank, Shoal and Reef

A bank is more or less flat topped elevation located in the continental margins. The depth of water over a bank is relatively small but is adequate for navigation. The Dogger Banks in the North Sea and the Grand Banks in the north western Atlantic off New Foundland and the George's Bank off the eastern coast of U.S.A. are famous examples.

A Shoal is a detached elevation with such shallow depth that it is a danger to surface navigation. The shoal is neither composed of a rock nor coral. Sometimes it is associated with a bank. In the Dogger Banks, there are shoals

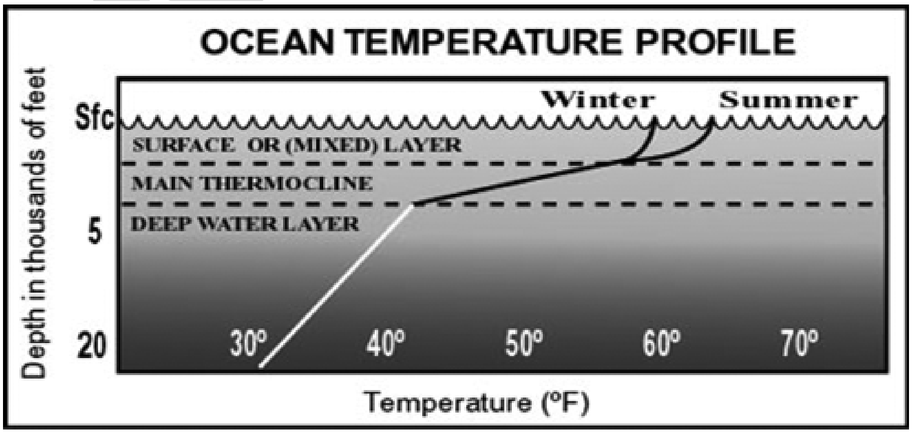


which are 18 m. above their surroundings and only 20 m. below the water surface.

A reef is a rocky or coral elevation having a generally elongated shape. There are many well known types of reefs such as fringing reef, barrier reef, coral reef and atoll. The longest barrier reef known as the Great Barrier Reef extends off the Queensland coast of Australia.

Shoal	Bank
(i) It is a bank of coastal sediment that rises almost to the surface of the sea. (ii) They may be only 20 metres below sea level and hence dangerous for navigation. (iii) They are not of much economic value to man.	(i) It is more or less flat topped elevation located in the continental margins. (ii) The depth of water over a bank though small but adequate for navigation. (iii) Dogger Banks in the North Sea and Grand Banks in the north west Atlantic ocean are famous fishing grounds.

TEMPERATURE OF THE OCEAN WATER



The temperature of the world's ocean is highly variable over the surface of the oceans, ranging from less than 0°C (32°F) near the poles to more than 29°C (84°F) in the tropics. It is heated from the surface downward by sunlight, but at depth most of the ocean is very cold. Seventy five percent of the water in the ocean falls within the temperature range of 1° to +6°C (30 to 43°F) and the salinity range of 34% to 35%.

The top part of the ocean water is called the surface layer. Then there is a boundary layer called the thermocline layer. The thermocline layer separates the surface layers and the deep water of the ocean.

The sun hits the surface layer of the ocean, heating the water up. Wind and waves mix this layer up from top to bottom, so the heat gets mixed downward too. The temperature of the surface waters varies mainly with latitude. The polar seas (high latitude) can be as cold as -2 ºCelsius (28.4º F) while the Persian Gulf (low latitude) can be as warm as 36 º Celsius (96.8º F). The average temperature of the ocean surface waters is about 17° Celsius (62.6° Fahrenheit). 90 % of the total volume of ocean water is found below the thermocline layer in the deep ocean. Water in the deep ocean is not well mixed. The deep ocean is made up of horizontal layers of equal density. The temperature of much of this deep ocean water is between 0°C and 3°C (32°F - 37.5 °F). The average annual temperature of ocean water at different latitudes is:

At equator	-	26°C
20° Latitude	-	23°C
40° Latitude	-	14°C
60° Latitude	-	1°C

Variations in total salinity and in temperature cause variations in the density of sea water. Cold sea water is denser than warm sea water. There are several areas at the ocean surface where surface water becomes very cold. In these locations, surface sea water becomes denser than the surrounding water and sinks to begin the formation of slow thermohaline currents, which move deep ocean water.

At depth, pressure from the overlying ocean water becomes very high (pressure at 4,000 meters is about 400 atmospheres), but water is only slightly compressible, so that there is only a minor pressure effect on density. At a depth of 4,000 meters, water decreases in volume only by 1.8 percent.

The horizontal distribution of the temperature of ocean water depends upon the following factors:

1. Latitudinal Distance

Temperature of the ocean water decreases from equator towards the poles. The average temperature of ocean water is 26°C in open seas at equator but the temperature decreases to 23°C at 20° North and South latitudes. Temperature further decreases to 14°C at 40° latitudes and to 1°C at 60° latitudes.

2. Unequal distribution of land and water

The temperature of ocean water varies in the northern and southern hemisphere because of dominance of land in the former and water in the latter. The oceans in the northern hemisphere receive more heat due to their contact with larger extent of land, thus temperature is comparatively high.

3. The Effect of Ocean Currents

The temperature of warm current is higher than that of the surrounding areas. The warm currents keep the coastal lands warmer. For example, the Gulf Stream does not allow the Norway Coast to freeze even in winter and thus helps the development of trade and commerce in that country. The temperature between Davis Strait and New Foundland drops down because of cold Labrador Current washing the coasts.

4. Prevailing Winds

The prevailing winds deflect the warm and cold currents and causes change in temperature of ocean water. For example, the currents on the east coast in the Trade Wind Belt shift away from the coast. Hence, the warm currents flowing along the coast moves away from it which leads to the upwelling of cold water from below near the coast. Hence the temperature remains low in spite of the passage of warm currents. This is why the temperature remains lower on the eastern than on western parts of the oceans.

5. Iceberg

Icebergs are found near polar areas and can be seen to be floating up to 50° latitudes. One part of iceberg is above sea and eight parts remain submerged under sea water. Many icebergs have a height of hundreds of metres above sea level. Thousands of icebergs can be seen moving away from North Atlantic. The Falkland and Benguela currents carry them to far off places. It lowers the temperature of the water to a great depth.

6. Local Weather

Local weather comprises different types of storms, cloudiness, precipitation and other weather conditions. In the equatorial regions, despite the vertical rays of the sun, large amount of cloudiness obstructs the solar radiation from reaching the earth surface.

It is due to the clear sky that near the Tropic of Cancer and the Tropic of Capricorn the amount of solar radiation incident on the earth exceeds that reaching the equatorial regions.

Thus, in the subtropical high pressure belt the surface water temperature in the oceans is a little higher. Besides, the incidence of daily afternoon rains in the equatorial regions does not allow the temperatures to rise further, whereas the extremely dry weather and cloudless skies prove helpful in raising the temperatures in the subtropical regions. In the same way in regions of stormy weather the ocean water temperatures are relatively lower.

7. Minor factors

Other minor factors which also control the sea surface temperatures are: Location of the seas and their shapes, submarine ridges, the rates of evaporation and condensation, etc.

SALINITY OF THE OCEAN WATER

The salinity of water is usually expressed in parts per thousand by weight (%) and is due to the presence of compounds of sodium, potassium, magnesium, calcium and other elements including a high proportion of sodium chloride (common salt). Rivers derive minerals from rocks and carry them to the sea. The salinity varies with the amounts of salts contributed, addition of fresh water by rainfall, rivers, and melting ice, and also with the rate of evaporation: rapid evaporation can cause relatively high surface salinity in open oceans.

Controlling factors of salinity

I. Rate of evaporation:

The process of evaporation is certainly the most important factor that controls the distribution of the surface salinity. Evaporation causes concentration of salt. Highest salinity is found near the tropics, because of active evaporation owing to clear sky, high temperature and steady trade winds. Salinity decreases towards the equator because of heavy convectional rainfall.

Salinity is higher in the middle-latitude regions than in the polar regions mainly because of warmer ocean temperatures and greater evaporation there (mid - latitudes). Due to the extremely low evaporation rates, on the contrary, the lowest salinity is found in polar areas. Besides, during the summer season, the polar area ice melts and fresh water is added to the seawater. Thus, the salinity decreases in the polar region.

II. Supply of clean and fresh water through precipitation:

In humid regions where rainfall is heavier, fresh water tends to dilute the sea-water and reduce its salinity. On the other hand, in arid and semi-arid areas where evaporation exceeds precipitation, there is greater concentration of salts so that the salinity is high.

In the equatorial region despite uniformly high temperature throughout the year, heavy precipitation dilutes the surface water so that the salinity is relatively lower. In the polar and sub polar regions thick layers of snow and ice are deposited on the surface of the earth due to heavy snowfall.

Melting of sea-ice and ice-bergs in the middle-latitude regions adds fresh water to the sea, and thus by diluting it reduces its salinity.

III. Supply of fresh water by rivers:

The influx of fresh water by river is another important factor which brings down the degree of salinity in ocean water. Rivers such as, the Congo, Niger, St. Lawrence, Ob and Amazon etc. carry a large supply of fresh water to the oceans in which they fall. Due to the addition of fresh water, salinity near the mouths of rivers decreases.

It is estimated that the rivers pour down about 27000 km3 of the rain water every year from over the continental surface into the oceans. Thus, keeping in view the total area of the surface of ocean waters, rivers supply about 7.6cm of fresh water per year to the oceans.

However, the effect of fresh water carried by the rivers to the oceans is limited to the coastal areas only. Salinity in the coastal areas of the North Sea from Holland to East Anglia is 34.2%, while offshore in the open sea it is 35%.

In the Black Sea over the greater part the surface salinity vanes from 18 to 18.5% due to the influx of fresh water carried by the rivers. Similarly, in the Baltic Sea lying in the colder region evaporation is comparatively low and a large amount of fresh water is poured down by numerous rivers of Sweden and northern Russia.

Thus, in the Gulf of Bothnia, in the northern part of the Baltic Sea the salinity is often less than 2%, and in spring the water is almost fresh.

IV. Prevailing winds:

Winds blowing over the sea surface play an important role in the distribution of surface salinity. For example, the trade winds in both the hemispheres transport warm and saline water from the eastern part of the oceans towards the western part raising the degree of salinity there.

To compensate for the loss of the top layers of the ocean water there, the cooler and less saline water from the deeper parts of the ocean comes up. This phenomenon is called upwelling.

The trade winds go a long way in producing salinity differences along the eastern and western shores of the oceans. Similarly, the intrusion of warm and saline water of the Gulf Stream is the most important causative factor in raising the salinity in the northeast Atlantic Ocean.

Besides, blowing of winds on the sea surface exerts stress, and each moving layer of water exerts a stress on the next underlying layer. Since it causes mixing of the different layers of water, it is enough to appreciate the dominant role of prevailing winds as a controlling factor in the distribution and amount of salinity.

V. Mixing through the movement of the ocean water:

The currents, stirred by wind, sweep away saline water from the eastern coast of the high latitudes to the western coasts, whereas cold water penetrates into the low latitudes. Thus there is a tendency for salinity to increase from east to west. Salinity is higher in enclosed seas as compared to open seas. The salinity of the Red Sea is 40% and that of the Dead Sea is 2.28%. This is because of high rate of evaporation, lack of supply of fresh water in enclosed seas.

Ocean currents alone is an important factor in bringing about the uniformity of salinity in the surface layer of the oceans. Currents, warm as well as cold, play a major role in the distribution of salinity.

Warm ocean currents carry warm and more saline waters towards the Polar Regions, whereas the cold currents drive the cold and less saline waters from the higher to lower latitudes.

Trade winds as well as the westerlies bring about salinity differences on the eastern and western parts of the oceans. However, in the Indian Ocean, the monsoon system of winds causes the seasonal variation in the distribution of salinity.

Composition of Sea Water

Sodium Chlorate	-	77.5%
Magnesium Chloride	-	10.9%
Magnesium Sulphate	-	4.7%
Calcium Sulphate	-	3.6%
Potassium Sulphate	-	2.5%
Calcium Carbonate	-	0.3%
Magnesium Bromide	-	0.2%

Distribution of salinity

Horizontal Distribution of Salinity refers to latitudinal distribution of salinity in water which is represented by ischalines. Ischalines are imaginary lines drawn on the map to represent the area of uniform salinity of the ocean water.

Pacific Oceans

There is a wide range of salinity difference in the Pacific Ocean because of its shape and larger arial extent salinity remains 34.85gm/kg between 15 to 20 degree latitudes in the northern hemisphere but it becomes still higher 36/kg in the latitudes. Salinity again decreases further northward in the western part the pacific ocean where it became 31gm/kg in the

Okhotsk sea and 34gm/kg near Manchuria (Northeast Asia) because of influx of melt water salinity also decreases along the California, middle America and Peruvian coast due to transfer of water and upwelling of cold water from below.

Atlantic Ocean

The average salinity of Atlantic Ocean is 35gm/kg the highest Salinity is not observe at the equator rather is recorded between 15°-20° latitudes .The central zone of north Atlantic Ocean located between 20° North-30° North and 20° West-60° West latitudes record maximum salinity 37gm.kg and it gradually decreases northward but with varying tender maximum salinity 37gm/kg in the southern Atlantic is from in a region marked by 12°S-20°S latitudes and 40°W-15°W longitudes, salinity, therefore gradually decreases southward. The pattern of special distribution of salinity in spite difference in partially enclosed sea of the Atlantic Ocean the north sea in spite of its location in high latitudes record 34gm/kg salinity due to more saline water brought by north Atlantic Drift further northward salinity continues to become as lower to 2gm/kg in the gulf of Bostonian (Finland west & Sweden East) due to influx of fresh water, the Mediterranean sea record high salinity due to evaporation and mixture of Atlantic water.

Indian Ocean

The special distribution of salinity in the Indian Ocean is more variable and complex than the Pacific and Atlantic Oceans and average Salinity of 35gm/kg is between 0'010°N but it gradually decreases northwards in the Bay of Bengal 33gm/kg because of influx of volume of fresh water brought by Ganga River. The western coast of Australia records high salinity due to dry weather the partially enclosed sea has high salinity for e.g., Persian gulf 40gm/kg the Red sea 36gm-41gm/kg because of low precipitation and very high evaporation.

Vertical Distribution of Salinity refers to the distribution of salinity with respect to depth of ocean, salinity generally increases towards the bottom of the ocean but there is no definite rule for decrease in the salinity, factors like temperature to latitudes ocean currents, upwelling and down willing influence the salinity of the ocean.

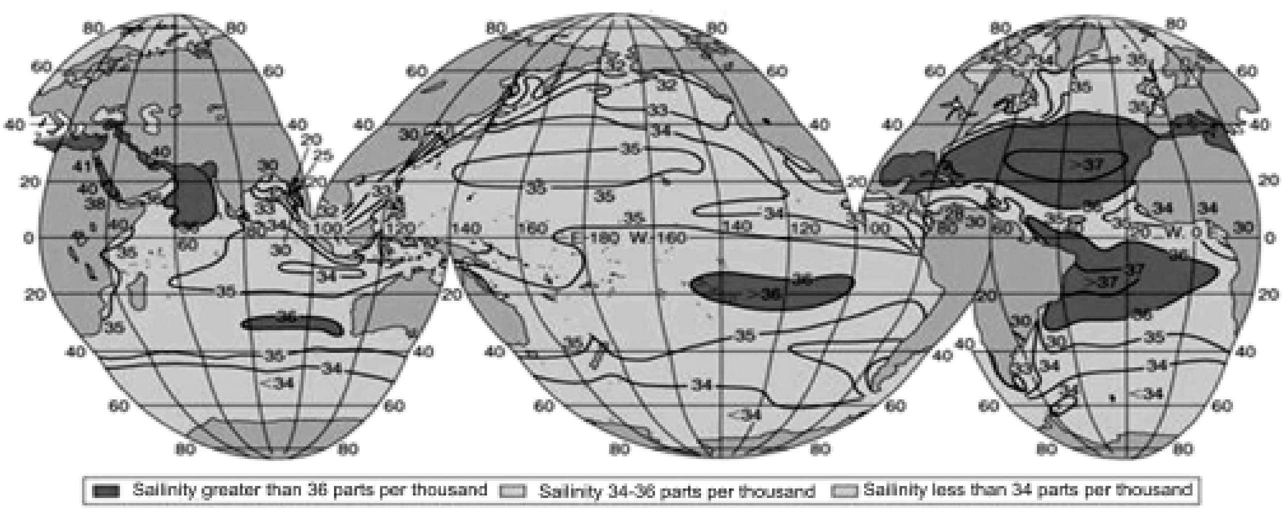
The Main features are:-

1. *Upper surface has lower salinity than bottom surface.*

2. *In equatorial region heavy rainfall reduces the surface salinity which gradually increases with depth until it starts decreasing again due to pressure of cold water.*

3. *In middle latitude salinity decreases up to 35m and then starts increasing*

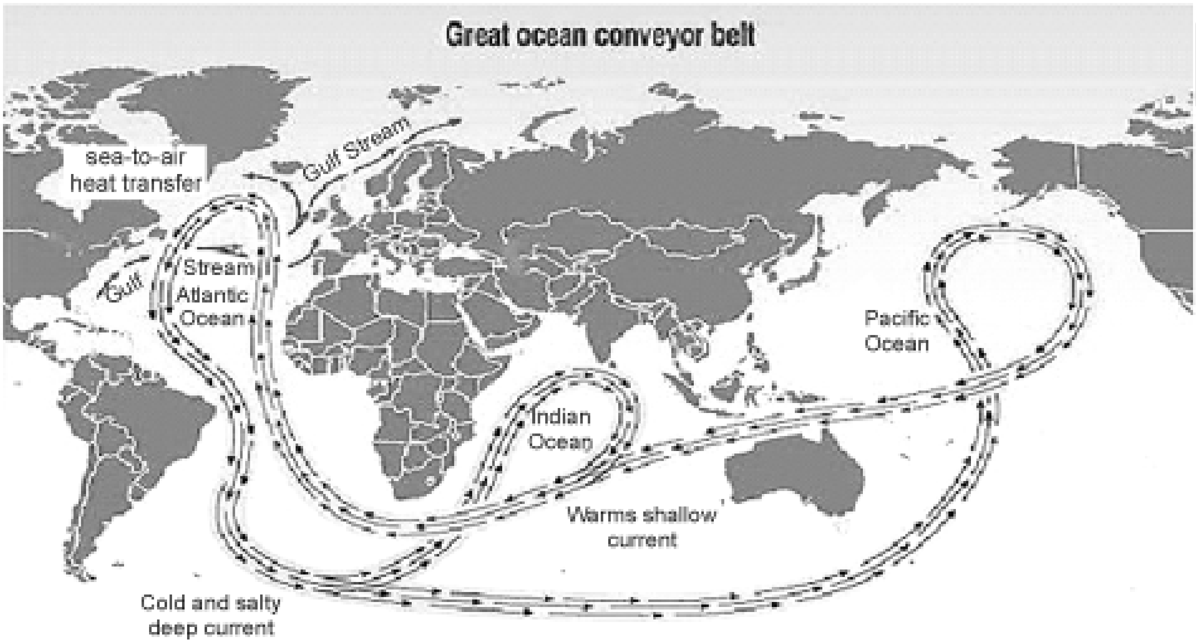
4. *In the high latitude or polar area surface salinity is low due to melting of icebergs and glaciers while salinity increases with the depth.*



THERMOHALINE CIRCULATION

Thermohaline circulation simply refers to global density-driven circulation of the oceans. Heat (thermo), and haline (density) are the two main factors determining the density of seawater.

Temperature and density share an inverse relationship so when the surface currents (i.e. the Gulf Stream) flow towards the poles from the equatorial Atlantic Ocean, they are cooled and flow downhill into deep water basins forming the North Atlantic Deep Water. These currents resurface in the northeast Pacific Ocean 1,200 years later. Ocean water from all of the ocean basins mixes thoroughly, carrying heat energy and matter in the form of solids and gases, making Earth's ocean a global system.



Formation of the deep water masses

The cold, dense water masses that sink into deep basins are formed in the North Atlantic and the Southern Ocean. Seawater is cooled by the wind and the salinity of the water increases due to the salt fraction of the water being left behind when the ice forms. Extremely dense brine is formed in ice pockets similar to a honeycomb. The brine drips down slowly through the honeycomb matrix and sinks to the sea bottom, flowing downhill through the bottom topography like a stream in the ocean to fill up the polar sea basins.

The cooling effect of the wind is a major factor in the Norwegian Sea and the North Atlantic Deep Water (NADW), where cold dense water fills the basin and spills southwards through crevasses that connect Greenland, Iceland and Britain.

In contrast, in the Weddell Sea located north of Antarctica near the edge of the ice pack, the effect of wind cooling becomes more intense with the exclusion of the brine. The result is the sinking and northward flow of the Antarctic Bottom Water (AABW)-seawater so dense that it actually flows underneath the North Atlantic Deep Water.

Movement of deep water masses

The North Atlantic Deep Water, is the result of density variation in the North Atlantic and is not a static mass of water like once thought, but instead a slowly southward flowing current. The route of the deep water flow is through the Atlantic Basin around South Africa and into the Indian Ocean and on past Australia into the Pacific Ocean Basin. Flow into the Pacific is blocked for both the AABW and the NADW, so the NADW flows very slowly into the deep abyssal plains of the Atlantic always in a southerly direction and the AABW also flows away from the road block. In the case of the AABW, the blockage is the Drake Passage, located between the Antarctic Peninsula and the southernmost tip of South America.

Upwelling

With all the dense water masses sinking in the ocean basins, the original water is moved upwards to keep a balance. Although thermohaline upwelling is a major factor causing ocean currents, it is also a very slow process, even when compared to the movement of bottom water masses. With all of the wind-driven processes going on simultaneously, it can be very complicated to determine where upwelling occurs just by using current speeds. So instead, we have to look at the breakdown of particulate matter that falls into the basins over their long journey, a sort of chemical signature. By analyzing the chemical and isotopic ratio signatures, the flow rate and age of the deep water masses can be determined. This signature tells us that the surface waters of the North Pacific is where most upwelling occurs.

Impacts on global climate

Thermohaline circulation is responsible for much of the distribution of heat energy from the equatorial oceans to the polar regions of the ocean. It is also the return flow of the sea water from the surface North Atlantic Drift and Gulf Stream currents.

OCEAN CURRENTS

Ocean currents are the vertical or horizontal movement of both surface and deep water throughout the world's oceans. Currents normally move in a specific direction and aid significantly in the circulation of the Earth's moisture, the resultant weather, and water pollution.

Oceanic currents are found all over the globe and vary in size, importance, and strength. Some of the more prominent currents include the California and Humboldt Currents in the Pacific, the Gulf Stream and Labrador Current in the Atlantic, and the Indian Monsoon Current in the Indian Ocean.

Surface currents are those found in the upper 400 meters (1,300 feet) of the ocean and make up about 10% of all the water in the ocean. Surface currents are mostly caused by the wind because it creates friction as it moves over the water. This friction then forces the water to move in a spiral pattern, creating gyres. In the northern hemisphere, gyres move clockwise and in the southern they spin counterclockwise. The speed of surface currents is greatest closer to the ocean's surface and decreases at about 100 meters (328 ft) below the surface.

As surface currents travel over long distances, the Coriolis force also plays a role in their movement and deflects them, further aiding in the creation of their circular pattern. Finally, gravity plays a role in the movement of surface currents because the top of the ocean is uneven. Mounds in the water form in areas where the water meets land, where water is warmer, or where two currents converge. Gravity then pushes this water down slope on the mounds and creates currents.

Deep water currents, also called thermohaline circulation, are found below 400 meters and make up about 90% of the ocean. Like surface currents, gravity plays a role in the creation of deep water currents but these are mainly caused by density differences in the water.

Causes of Ocean Currents

There are several causes for ocean currents, including:

a) *Solar Activity*

This is the single most important cause. The Sun provides the bulk of the energy which drives the circulation of water in the oceans, either directly or indirectly (through winds). The uneven distribution of solar energy across the globe (highest at the equator, decreasing towards the poles) produces an uneven heating of water in the ocean. Like air, hot water expands. The differential heating is so pronounced that sea level at the equator is about 8 cm (3.15 inches) higher than at temperate latitudes.

b) Gravity

The equatorial bulge of the oceans, caused by the expansion of water under equatorial heat creates a slope, and water tends to run downhill under the force of gravity. This is one of the major reasons for surface water flow from the equator towards higher latitudes.

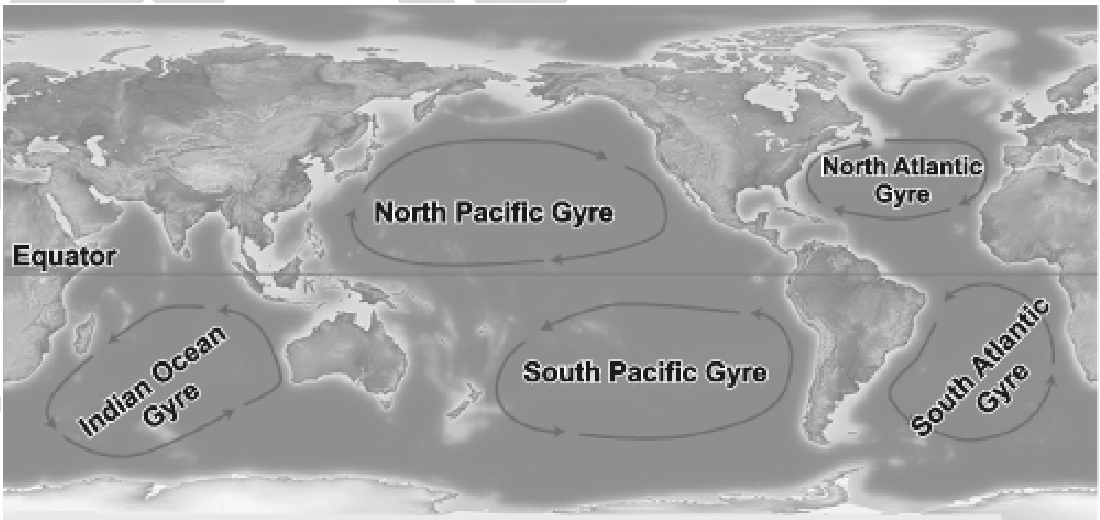
c) Winds

Winds produce a flow of water at the ocean surface due to frictional coupling between the wind and the surface of the oceans. Since the oceans are largely flat unobstructed by topography, winds can blow for long distances, for prolonged periods of time. Friction between the air and the surface of the water is sufficiently high, that a wind blowing for about 10 hours can produce a surface current in the water at about 2% of the wind velocity. So a steady wind blowing in a certain direction at 20 miles per hour for about 10 hours will produce a surface water current at about 0.4 miles per hour. The direction of the water current is not the same as that of the wind flow. The direction of the water current is affected by a phenomenon known as Eckman Transport. Briefly, a column of water can be thought of as consisting of many layers. Wind friction affects the topmost layer, pulling the water in the direction of wind flow. This top layer of water tends to pull layers of water beneath, but because of the Coriolis force the water actually moves at an angle to the side. In progressively deeper layers, the sideways movement is enhanced, so the entire water column can been thought of as moving in a spiral. The net flow of water is almost at right angles to the direction of the wind.

The duration of the wind is very significant. Since water is much heavier than air, it also has much more inertia. Short duration winds only produce turbulence at the water's surface. It takes winds blowing over a longer duration to produce a sustained movement of water in the wind's direction.

d) Coriolis force and Ocean Gyres

This is a pseudo force resulting from the Earth's rotation from west to east about its axis. Because of the Earth's rotation, any movement away from the equator (in both the northern and southern hemispheres) is deflected eastwards, while movements towards the equator are deflected westwards. This effect is very pronounced in movements that happen within a fluid medium (atmosphere and oceans), and over long distances. Because of the Coriolis Effect, currents tend to flow in curves rather than in straight lines. When the space for movement is restricted (such as by land bounding the oceans), these curves can close in on themselves, and cause a circular flow of water around a center. Such circular flows are called oceanic gyres.



The five major Ocean Gyres circulations is clockwise north of the Equator & Anticlockwise South of the Equator

Gyres are usually bounded by the shallow waters of continental shelves. There are five major gyres in the world's oceans, which are delimited by the continents around them.

These gyres are responsible for much of the world's surface currents. As you can see in the map above, much of the eastern coast of Africa has a current going from north to south, part of the Indian Ocean Gyre. This current was a great problem to early European navigators, trying to go around the Cape of Good Hope (the southern tip of Africa) to find a trade route to India. Early sailing ships tended to hug the coast, where the currents are strongest, and they didn't have a lot of motive power in the days of sail. Even today, ships use these currents to save fuel, since making way against the current is costly. Debris floating in the ocean also tends to converge in certain zones because of these currents. The North Atlantic Garbage Patch and the Great Pacific Garbage Patch are places where a lot of trash dumped into the oceans has aggregated.

Ocean currents in Atlantic Ocean

Circulation of surface water is generally clockwise in the North Atlantic and counterclockwise in the South Atlantic. There are, however, many exceptions to the general circulation, particularly along the coasts.

In the North Atlantic, the strongest current is the warm Gulf Stream, which forms in the Gulf of Mexico. It flows north-eastward off the United States coast, encounters the cold Labrador Current from the north, and continues across the Atlantic as the North Atlantic Current, or Drift. It continues northward as the Irminger and Norwegian currents.

West of Spain, part of the North Atlantic Current turns southward, flows along the "bulge" of Africa as the Canaries Current, then turns westward as the North Equatorial Current. This current crosses the ocean; part of its water reaches the Gulf of Mexico. South of the North Equatorial Current, running in the opposite direction, is the Equatorial Counter-current. In the western North Atlantic, around Bermuda, is the Sargasso Sea, a calm area named for its masses of floating sargassum weed.

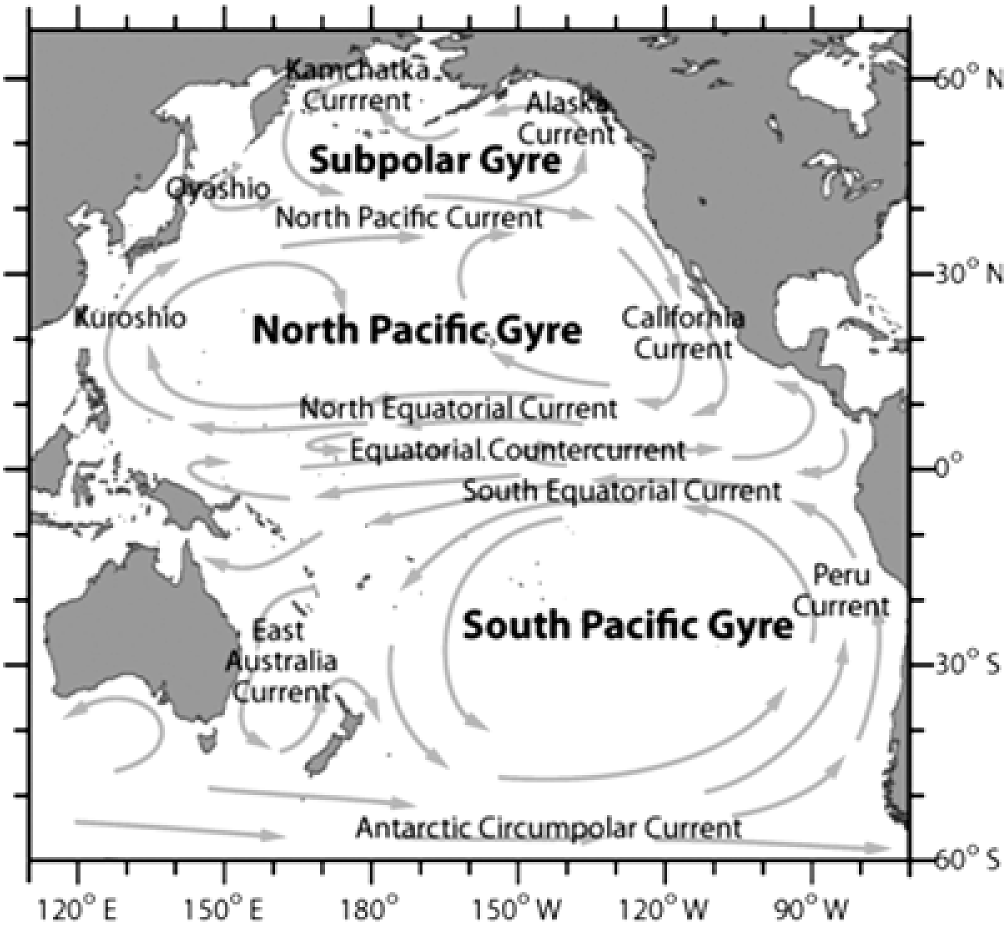
In the South Atlantic, the cold Benguela Current flows northward up to the coast of Africa, turns west near the Equator, and flows westward as the warm South Equatorial Current. Near the South American coast, part of the current swings southward to become the Brazil Current, which runs down the coast of South America to about 40° South latitude. Here, it meets the cold Falkland Current. Flowing eastward across the South Atlantic in a broad belt around 50° S. is the West Wind Drift.

Ocean Currents in Pacific Ocean

General circulation of the currents is clockwise in the North Pacific, counterclockwise in the South Pacific. It is somewhat like the rotations of two giant disks turning in opposite directions. As a result, warm equatorial water is constantly being carried poleward along the Asian and Australian coasts, while cold water is flowing toward the equator along the coasts of North and South America. Thus, the currents have distinct climatic effects on nearby lands. In some areas, such as the coast of Chile and Peru, currents have cooling effects; in others, such as southern Japan, they are warm. In regions where warm and cold currents meet, notably northern Japan to southern Alaska, dense fogs frequently occur.

The chief currents of the North Pacific, beginning at the equator, are the North Equatorial Current, Kuroshio (Japan Current), North Pacific Current, or Drift, and California Current. Entering this circulation from the Arctic is the cold Oyashio (Okhotsk, or Kamchatka, Current). The Alaska Current starts off the coast of Oregon and flows northward along the coast of North America as far as Kodiak Island, bringing warmth to the coastal areas in winter. In the South Pacific are the South Equatorial Current, East Australian Current, West Wind Drift, and Peru (Humboldt) Current. Separating the two systems in the vicinity of the equator is the Equatorial Counter-current, which flows eastward from Indonesia and the Philippines to the South American coast.

There are also deep, underwater currents, but little is known of them. They tend to form separate layers flowing in different directions, each layer being denser than the layer above. For example, Antarctic water is known to subside suddenly beneath warmer water at a line called the Antarctic Convergence. From here it flows northward far below the surface of the ocean.



Ocean currents in Indian Ocean

The Asiatic Monsoon influences the currents of the North Indian Ocean, while the currents of the South Indian Ocean are influenced by the atmosphere's anticyclonic circulation.

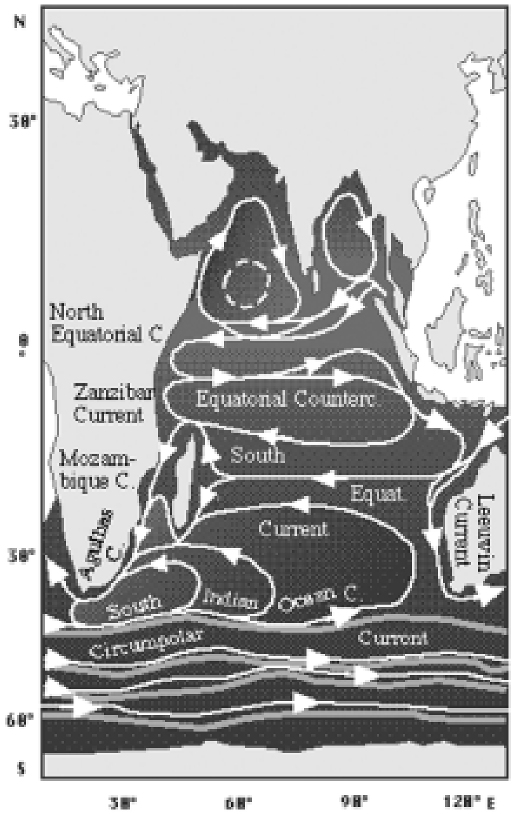
During the northwest monsoon (February and March) the wind blows from the continent and aids in the development of the North Equatorial Current. The current flows from east to west; and upon reaching the east coast of Africa, a good portion turns southward, crosses the equator, and becomes the Mozambique Current. A strong counter-current exists south of the North Equatorial Current at this same time of year. In August and September, during the southwest monsoon, the North Equatorial Current reverses and flows west to east as the Monsoon Current. At the same time, the countercurrent seems to disappear.

The Mozambique Current flows south along the east coast of Africa from the vicinity of the equator to about 35°S, where it is known as the Alguhas Stream.

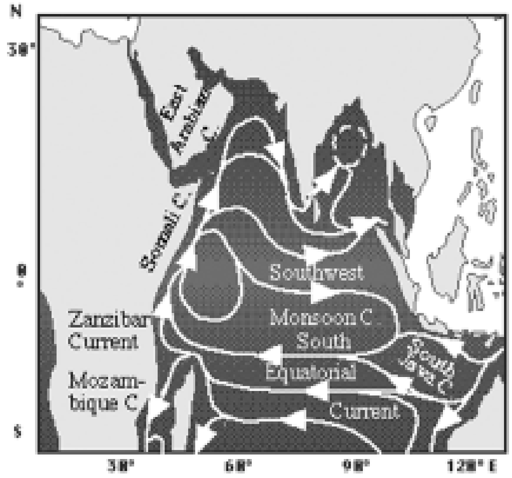
The Alguhas Stream flows westward along the southern coast of Madagascar and joins the Mozambique Current along the east African coast. From there, it flows south to the southern tip of Africa (the Cape of Good Hope), where a good portion joins up with the West Wind Drift Current.

The West Wind Drift Current flows across the Indian Ocean to the waters southwest of

Australia. Here it splits; one branch continues east along the southern coast, while the other flows northward along the western coast. This branch brings relatively cool waters to the western Australian coast and contributes to the formation of fog and low stratus clouds over the region.



Indian Ocean



left: Northeast Monsoon season (March/April)

right: Southwest Monsoon season (Septemer/October)

The Importance of Ocean Currents

Because ocean currents circulate water worldwide, they have a significant impact on the movement of energy and moisture between the oceans and the atmosphere. As a result, they are important to the world's weather. The Gulf Stream, for example, is a warm current that originates in the Gulf of Mexico and moves north toward Europe. Since it is full of warm water, the sea surface temperatures are warm, which keeps places like Europe warmer than other areas at similar latitudes.

The Humboldt Current is another example of a current that affects weather. When this cold current is normally present off the coast of Chile and Peru, it creates extremely productive waters and keeps the coast cool and northern Chile arid. However, when it becomes disrupted, Chile's climate is altered and it is believed that El Niño plays a role in its disturbance.

Like the movement of energy and moisture, debris can also get trapped and moved around the world via currents. This can be man-made which is significant to the formation of trash islands or natural such as icebergs. The Labrador Current, which flows south out of the Arctic Ocean along the coasts of Newfoundland and Nova Scotia, is famous for moving icebergs into shipping lanes in the North Atlantic.

Currents play an important role in navigation as well. In addition to being able to avoid trash and icebergs, knowledge of currents is essential to the reduction of shipping costs and fuel consumption. Today, shipping companies and even sailing races often use currents to reduce time spent at sea.

Finally, ocean currents are important to the distribution of the world's sea life. Many species rely on currents to move them from one location to another whether it is for breeding or just simple movement over large areas.

TIDES

The tide is the periodic rise and fall of the sea levels caused by the combined effects of the gravitational forces exerted by the Moon and Sun and rotation of the earth. Most places in the ocean usually experience two high tides and two low tides each day (semidiurnal tide), but some locations experience only one high and one low tide each day (diurnal tide). The times and amplitude of the tides at the coast are influenced by the alignment of the Sun and Moon, by the depth of the ocean, and by the shape of the coastline and near-shore bathymetry.

The moon, which is approximately 240,000 miles (386,240 km) from the earth, exerts a greater influence on the tides than does the sun, which is 93 million miles (150 million km) from the earth. The strength of the sun's gravity is 179 times that of the moon's but the moon is responsible for 56% of the earth's tidal energy while the sun claims responsibility for a mere 44%.

When the moon exerts gravitational force on the earth the tidal bulge moves out and causes high tide. Simultaneously on the side opposite to that place on the earth i.e. just at 180° to it, also experiences the tidal bulge due to reactionary force (centrifugal) of the gravitational (centripetal) force. Thus two tides are experienced twice at every place on the earth's water surface within 24 hours.

Due to the cyclic rotation of the earth and moon, the tidal cycle is 24 hours and 52 minutes long.

Causes of Tides

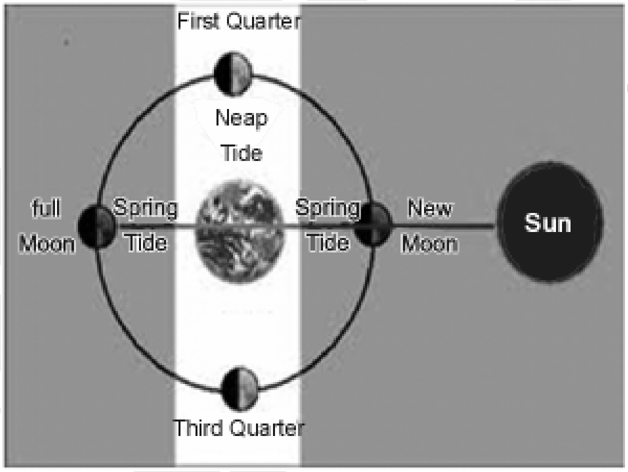
- *Gravitational attraction between moon and the earth.*
- *Gravitational attraction between sun and the earth.*
- *Attraction force of the earth towards earth centre.*
- *Moon is mainly responsible for the tides.*

Types of Tides

- ***Semi diurnal tides*** - *Recur at the intervals of 12½ hours.*
- ***Diurnal Tides*** - *Recur at the intervals of 24½ hours.*
- ***Spring Tides*** - *once a forthnight, due to the revolution of the moon and its declination.*
- ***Neap tides*** - *Once a forthnight due to the revolution and declination of moon.*
- ***Monthly tides*** - *Due to the revolution of the moon and its position at perigee and apogee.*

SPRING TIDES

Spring tides are especially strong tides or high tides. They occur when the Earth, the Sun,



and the Moon are in a line. The gravitational forces of the Moon and the Sun both contribute to the tides. Spring tides occur during the full moon and the new moon.

NEAP TIDES

Neap tides are especially weak tides. They occur when the gravitational forces of the Moon and the Sun are perpendicular to one another (with respect to the Earth). Neap tides occur during quarter moons.

The Bay of Fundy between Nova Scotia and New Brunswick in Canada experiences the world's greatest tidal range of 50 feet (15.25 meters)

OCEAN DEPOSITS

The sediments deposited in the oceans are derived from following major sources:

1. Terrigenous materials:

These are the deep-sea sediment transported to the oceans by rivers and wind from land sources.

Terrigeneous sediments that reach the continental shelf are often stored in submarine canyons on the continental slope. Turbidity currents carry these sediments down into the deep sea. These currents create sedimentary deposits called turbidites, which are layers up to several metres thick composed of sediment particles that grade upward from coarser to finer sizes. The turbidites build sedimentary deep-sea fans adjacent to the base of the continental slope. Turbidites are also found below the major river deltas of the world where they build features called abyssal cones. The largest of these is the Ganges Fan (also called the Ganges Cone or Bengal Cone) in the Bay of Bengal east of the Indian subcontinent. It measures 3,000 km (about 1,900 miles) long (north-south) by 1,000 km (about 600 miles) wide (east-west) and is up to 12 km (about 7 miles) thick. The Bengal Cone continues to form from rock material eroded from the Himalayas and transported by the Ganges and Brahmaputra rivers.

Abyssal plains are formed by the accumulation of turbidites beyond the limits of deep-sea fans and abyssal cones in locations where there is a very large sediment supply. In contrast to fans and cones, abyssal plains are flat and featureless. They are prominent near both margins of the Atlantic and in the northeast Pacific.

Some types are:

a) **Gravels:** The diameter of gravels Range from 2mm to 256mm. These are deposited near the coast on the continental shelves. These are further divided as boulders (256mm); cobbles (64mm); pebbles (4mm), granules (2mm), etc.

b) **Sands:** The sediments vary in size from 1mm to 1/16mm. The disintegration of continental rocks fragments into fine sediments produces sands which are deposited in the oceans by rivers, surface wash and winds.

c) **Clay and Mud:** These range from 1/32mm to 1/8192mm. clay and mud are deposited in calm seawater. Muds are further classified as: ***Blue mud,*** according to Murray and Renard, is usually of a blue or slatey or grey-green colour when fresh, the upper surface having, however, a reddish tint. The proportion of calcium carbonate varies greatly according to the amount of foraminifera and other calcareous organisms it contains. Blue mud prevails in large areas of the Pacific ocean, the Indian ocean, and the Atlantic. As a glacial-marine mud it occurs round the whole of the Antarctic shelf, down to depths of 4,500 metres. A blue and brown mud is the chief deposit of the North Polar basin and of the Norwegian sea also. Max Weber states that blue mud occurs in the deep basins of the eastern Malay sea. ***Red mud*** may be classed as a variety of blue mud, from which it differs on account of the larger proportion of ochreous sub stance. This variety surrounds the tropical parts of the conti nental shelves of South America, South Africa and eastern China. ***Green mud*** differs to a greater extent from the blue mud, and owes its characteristic nature and colour to the presence of glauconite, the spines of echini and the spicules of sponges. It occurs in such abundance in certain geological formations as to give rise to the name of green-sand. Green mud abounds off Cape Hatteras, the north of Cuba, and off the coast of California.

2. Volcanic materials

The volcanic materials are derived from volcanic eruptions either in the sea or on the land. Finer volcanic materials nearer to the coastal areas are blown by winds and carried to the oceans while volcanic materials of distinct places are brought by the rivers. These materials resemble blue mud and are grey to black in colour.

3. Organic materials

The source of marine organic deposit includes: skeletons of marine organisms and plant remains divided as neretic matter (skeletons of marine organisms and plant remains) and pelagic matter also known as oozes (remains of different kinds of algae).

Biogenic oozes *accumulate very slowly* in the deep ocean. This is because the surface waters of the central oceans are very poor in the nutrients (mostly land-derived), such as nitrogen and phosporus, that are required by the surface sea creatures. Therefore these waters are inhabited by only small populations which contribute very slowly to the development of the deep ocean sediment accumulation.

There are two major types of Oozes - siliceous and calcareous.

a) **Siliceous -** i.e. SiO_2 oozes are made up of the tests of floating (planktonic) organisms that extract silica from seawater to make their hard parts. The most abundant of these are the diatoms (plants) and the radiolarians (animals).

Nowhere, in the oceans does silica precipitate spontaneously without the intervention of an organism. Therefore, the tendency for silica is to dissolve everywhere it occurs in the oceans. So, the only regions in which siliceous oozes are abundant are in regions where the nutrient supply is so large that diatom and radiolarian tests accumulate faster than the seawater can redissolve them after death.

These regions are along the Equator in the central Pacific and in high latitudes near Antarctica. The high dilution by terrigenous sediment input and extensive ice cover in northern latitudes inhibiting high biological productivity limit siliceous ooze accumulation in northern latitudes. It dominates about 14% of Deep Ocean.

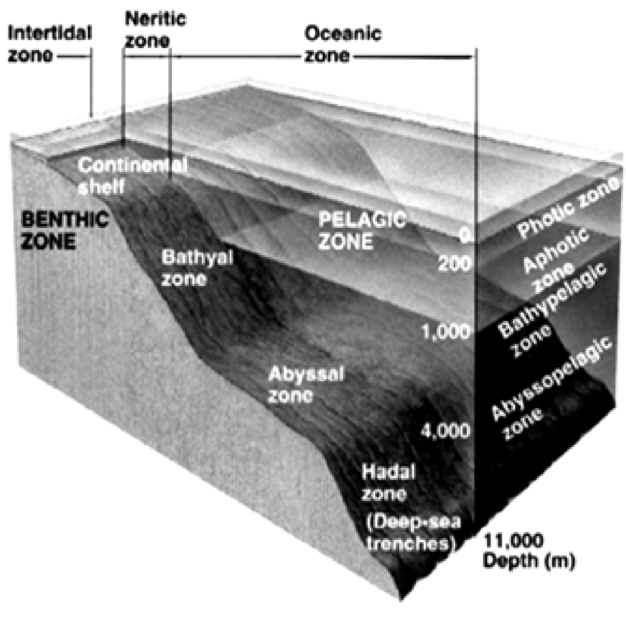
b) **Calcareous oozes** - $CaCO_3$ made up of the tests of floating (planktonic) organisms that extract $CaCO_3$ from seawater to make their hard parts. $CaCO_3$ precipitates spontaneously in some oceanic regions without the intervention of an organism (WHITING). In warm tropical surface waters $CaCO_3$ does not readily dissolve. However, in colder deeper waters the presence of increased amounts of CO_2 in the water enhances the dissolution of $CaCO_3$ causing the breakdown of calcareous tests.

The carbon dioxide and water combine to form carbonic acid which dissolves the $CaCO_3$. At lower latitudes, $CaCO_3$ dissolves at depths in the ocean where it encounters these CO_2-rich water masses. The depth below which calcareous skeletons dissolve as fast as they accumulate is called as **calcium carbonate compensation depth (ccd).** In warm latitudes the CCD occurs at 4-5 kilometers. Therefore, calcareous oozes will be found only at depths less than 4-5 kilometers. Where the bottom of the ocean is deeper than 4-5 kilometers calcareous tests will not accumulate. Calcareous oozes, therefore, are found mostly on the oceanic ridges and plateaus.

4. Red Clay

Red clay, also known as either "brown clay" or "pelagic clay," accumulates in the deepest and most remote areas of the ocean. It covers 38% of the ocean floor and accumulates more slowly than any other sediment type, at only 0.1-0.5 cm / 1000 yr. Containing less than 30% biogenic material, it consists of sediment that remains after the dissolution of both calcareous and siliceous biogenic particles while they settled through the water column. These sediments consist of eolian quartz, clay minerals, volcanic ash, subordinate residue of siliceous microfossils, and authigenic minerals. The bulk of red clay consists of eolian dust. These pelagic sediments also contain authegenic minerals that include zeolites, limonite and manganese oxides. Accessory constituents found in red clay include meteorite dust, fish bones and teeth, whale ear bones, and manganese micro-nodules.

These pelagic sediments are typically bright red to chocolate brown in colour. The colour results from coatings of iron and manganese oxide on the sediment particles. In the absence of organic carbon, iron and manganese remain in their oxidized states and these clays remain brown after burial.



When more deeply buried, brown clay may change into red clay due to the conversion of iron-hydroxides to hematite.

These sediments accumulate on the ocean floor within areas characterized by little planktonic production. The clays which comprise them were transported into the deep ocean in suspension, either in the air over the oceans or in surface waters. Both wind and ocean currents transported these sediments in suspension thousands of kilometers from their terrestrial source. As they were transported, the finer clays may have stayed in suspension for a hundred years or more within the water column before they settled to the ocean bottom. The settling of this clay-size sediment occurred primarily by the formation of clay aggregates by flocculation and by their incorporation into fecal pellets by pelagic organisms.

CORAL REEFS

Coral Reefs referred to as the "rainforests of the oceans" are underwater structures made from secreted by corals. The reef is made up of thousands of corals. When coral dies, it leaves its skeleton of calcium carbonate behind. Young corals attach themselves to the old skeleton and the cycle starts again. Each new generation is built upon the remains of the previous generation.

The sun is the source of energy for the coral reef ecosystem. Plant plankton, called phytoplankton, algae and other plants convert light energy into chemical energy through photosynthesis. As animals eat the plants and other animals, energy is passed through the food chain. Reef building corals work together with microscopic algae, called zooxanthellae that live in their tissue. The zooxanthellae provide oxygen and food to the coral through photosynthesis. The coral polyp gives the algae a home, and the carbon dioxide it needs through respiration.

Coral bleaching occurs when corals lose their zooxanthellae, exposing the white calcium carbonate skeletons of the coral colony. There are a number of stresses or environmental changes that may cause bleaching including disease, excess shade, increased levels of ultraviolet radiation, sedimentation, pollution, salinity changes, and increased temperatures.

Suitable conditions for the growth of Coral Reef:

Coral reefs develop in shallow, warm water, usually near land, and mostly in the tropics; coral prefer temperatures between 70 and 85 °F (21 - 30 °C). Coral reefs are generally found in clear, tropical oceans. Coral reefs form in waters from the surface to about 150 feet (45 meters) deep because they need sunlight to survive.

Reefs usually develop in areas that have a lot of wave action because the waves bring in food, nutrients and oxygen to the reef. Waves also prevent sediment from falling on the reef. Reefs need calcium from the water to grow, which is more often available in shallow warm waters.

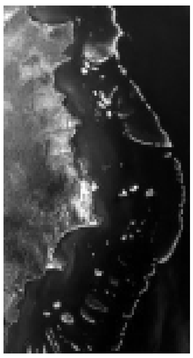
Corals can live only in saline water, and for their proper growth the average salinity should be between 27 to 40%.

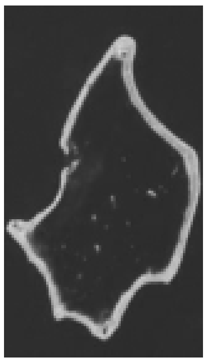
Types of Coral Reefs:

Reefs are generally classified in three types:

- *Fringing reefs are reefs that form along a coastline. They grow on the continental shelf in shallow water.*
- *Barrier reefs grow parallel to shorelines, but farther out, usually separated from the land by a deep lagoon. They are called barrier reefs because they form a barrier between the lagoon and the seas, impeding navigation.*
- *Coral Atolls are rings of coral that grow on top of old, sunken volcanoes in the ocean. They begin as fringe reefs surrounding a volcanic island; then, as the volcano sinks, the reef continues to grow, and eventually only the reef remains.*


FRINGING REEF


BARRIER REEF


ATOLL

The Great Barrier Reef is the largest coral reef comprising over 2,900 individual reefs and 900 islands stretching for over 2,600 kilometers off Queensland, Australia

The Mesoamerican Barrier Reef System is the second largest, stretching 1,000 kilometers (620 mi) from Isla Contoy at the tip of the Yucatán Peninsula down to the Bay Islands of Honduras.

The New Caledonia Barrier Reef is the second longest double barrier reef, covering 1,500 kilometers.

The Andros, Bahamas Barrier Reef is the third largest, along the east coast of Andros Island, Bahamas.

Coral reefs provide habitats for a large variety of organisms. These organisms rely on corals as a source of food and shelter. Besides the corals themselves and their symbiotic algae, other creatures that call coral reefs home include various sponges; molluscs such as sea slugs, nudibranchs, oysters, and clams; crustaceans like crabs and shrimp; many kinds of sea worms; echinoderms like star fish and sea urchins; other cnidarians such as jellyfish and sea anemones; various types of fungi; sea turtles; and many species of fish.

Coral reefs are dying around the world. In particular, coral mining, agricultural and urban runoff, pollution (organic and inorganic), overfishing, blast fishing, disease, and the digging of canals and access into islands and bays are localized threats to coral ecosystems. Broader threats are sea temperature rise, sea level rise and pH changes from ocean acidification, all associated with greenhouse gas emissions.

Major threats to the world's coral reefs include:

- Pollution
- Disease
- Over-fishing
- Dynamite and cyanide fishing
- Sedimentation
- Bleaching caused by rising ocean temperatures

MARITIME ZONES

The United Nations Convention on the Law of the Sea (UNCLOS), also called the Law of the Sea Convention or the Law of the Sea treaty, has divided the maritime area as internal waters, the territorial sea, the contiguous zone, the exclusive economic zone, the continental shelf, the high seas and the Area in 1982.

Maritime zones delineate the sovereignty or sovereign rights a coastal state has over the offshore environment.

The maritime areas are divided as:

Baseline:

A baseline is the line from which the seaward limits of a State's territorial sea and certain other maritime zones of jurisdiction are measured. Normally, a sea baseline follows the low-water line of a coastal State. When the coastline is deeply indented, has fringing islands or is highly unstable, straight baselines may be used.

Internal Waters:

Internal waters are the waters (for example, bays and rivers) on the landward side of the baseline. Each coastal State has full sovereignty over its internal waters as if they were part of its land territory. The right of innocent passage does not apply in internal waters. The coastal state is free to set laws, regulate use, and use any resource.

Territorial waters:

Territorial Water is a belt of coastal waters extending at most 12 nautical miles (22 km; 14 mi) from the baseline of a coastal state. The territorial sea is regarded as the sovereign territory of the state, although foreign ships (both military and civilian) are allowed innocent passage through it; this sovereignty also extends to the airspace over and seabed below.

"Innocent passage" is defined by the convention as passing through waters in an expeditious and continuous manner, which is not "prejudicial to the peace, good order or the security" of the coastal state. Fishing, polluting, weapons practice, and spying are not "innocent", and submarines and other underwater vehicles are required to navigate on the surface and to show their flag. Nations can also temporarily suspend innocent passage in specific areas of their territorial seas, if doing so, is essential for the protection of its security.

Contiguous Zone:

The contiguous zone is a band of water extending from the outer edge of the territorial sea to up to 24 nautical miles (44 km; 28 mi) from the baseline. In its contiguous zone, a coastal State may exercise the control necessary to prevent the infringement of its customs, fiscal, immigration or sanitary laws and regulations within its territory or territorial sea, and punish infringement of those laws and regulations committed within its territory or territorial sea. Additionally, in order to control traffic in archaeological and historical objects found at sea, a coastal State may presume that their removal from the seabed of the contiguous zone without its consent is unlawful.

Exclusive Economic Zone:

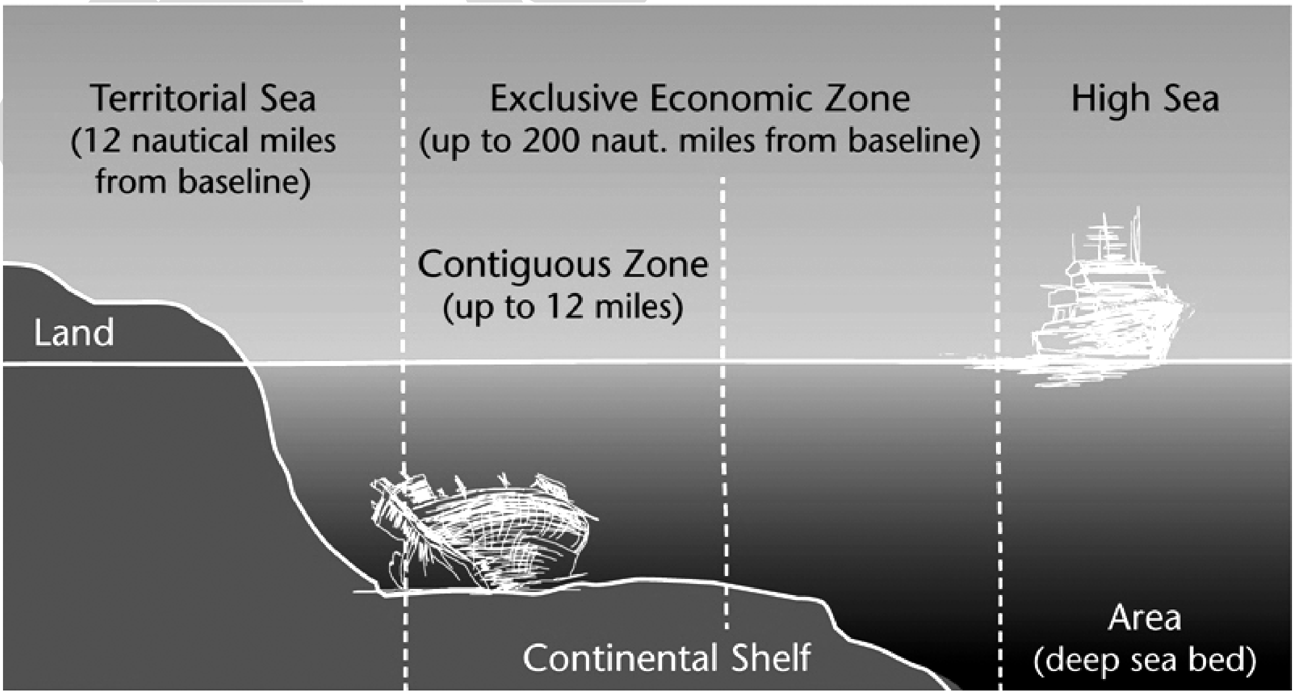
An exclusive economic zone extends from the outer limit of the territorial sea to a maximum of 200 nautical miles (370.4 km) from the territorial sea baseline, thus it includes the contiguous zone.

In the exclusive economic zone, the Union has- sovereign rights for the purpose of exploration, exploitation, conservation and management of the natural resources, both living and non-living as well as for producing energy from tides, winds and currents; exclusive rights and jurisdiction for the construction, maintenance or operation of artificial islands, off-shore terminals, installations and other structures and devices necessary for the exploration and exploitation of the resources of the zone or for the convenience of shipping or for any other purpose; Exclusive jurisdiction to authorize, regulate and control scientific research; Exclusive jurisdiction to preserve and protect the marine environment and to prevent and control marine pollution.

No person (including a foreign Government) shall, except under, and in accordance with, the terms of any agreement with the Central Government or of a licence or a letter of authority granted by the Central Government, explore or exploit any resources of the exclusive economic zone or carry out any search or excavation or conduct any research within the exclusive economic zone or drill therein or construct, maintain or operate any artificial island, off-shore terminal, installation or other structure or device therein for any purpose whatsoever. But it is not applicable to the citizens of the nation.

Continental Shelf:

Each coastal State has a continental shelf that is comprised of the seabed and subsoil of the submarine areas that extend beyond its territorial sea throughout the natural prolongation of its land territory to the outer edge of the continental margin, or to a distance



of 200 nm from its baselines where the outer edge of the continental margin does not extend up to that distance (or out to a maritime boundary with another coastal State).

Wherever the outer edge of a coastal State's continental margin extends beyond 200 nm from its baselines, it may establish the outer limit of its continental shelf in accordance with the UN Convention on the Law of the Sea. The portion of a coastal State's continental shelf that lies beyond the 200 nm limit is often called the extended continental shelf.

A coastal State has sovereign rights and exclusive jurisdiction over its continental shelf for the purpose of exploring it and exploiting its natural resources. The natural resources of the continental shelf consist of the mineral and other non-living resources of the seabed and subsoil together with living organisms belonging to sedentary species, that is to say, organisms which, at the harvestable stage, either are immobile on or under the seabed or are unable to move except in constant physical contact with the seabed or subsoil.

High Seas:

The high seas are comprised of all parts of the sea that are not included in the exclusive economic zone, in the territorial sea or in the internal waters of a State, or in the archipelagic waters of an archipelagic State.

Terminology

Continental Shelf: The area lying between shoreline and the continental slope. Its seaward slope is very gentle and is covered with shallow water.

Continental Slope: The area extending from the margin of the continental shelf to the deep sea floor, Its slope towards the sea floor is very steep.

Continental Rise: The gently inclined slope from the deep sea-floor to the foot of the continental slope.

Abyssal Plain: The area of deep ocean floor. These are deep sea plains.

Submarine Ridge: A ridge on the floor of ocean. It is a few hundred kilometres wide and hundreds and thousands of kilometres is length.

Seamount: A submarine mountain or peak rising more than 1000 metres above the ocean floor.

Guyot: A flat-topped seamount.

Submarine Trench: A long, narrow and steep sided depression on the ocean bottom.

Submarine Canyon: A deep gorge on the ocean floor.

Bank: A more or less flat topped elevation located in the continental margins. The depth of water over a bank is relatively small.

Reef: A line of rocks in the tidal zone of a coast submerged as high water but partly increased at low water.

Shoal: It is a detached elevation with shallow depth.

Salinity: The degree to which water contains dissolved salts.

Ice floats: The drifting ice fields. Their height is not more than four metres.

Icebergs: Huge masses of floating ice. Their height varies from 5 metres to 90 metres.

Waves: A deformation of water surface in the form of an oscillatory movement which manifests itself by an alternating rise and fall of that surface.

Currents: It is the general movement of a mass of water in a fairly defined direction over great distances.

Drift: The motion of ocean water generally at a low velocity, as a result of surface friction from the prevailing winds.

Tide: The regular rise and fall of water level in the world's ocean, resulting from the gravitational attraction that is exerted upon the earth by the moon and then sun.

Ecology: It is the study of interrelationship between the living system and the environment.

Environment: It includes the outer surrounding atmosphere of the living system.

Physical factor: These are the non-living factors of the environment.

Direct uses of oceans to man:

(a) Oceans are a great source of food supply, such as fish.

(b) Oceans are storehouse of minerals.

(c) Oceans provide the most important means of natural transport to the man.

Indirect uses of oceans to man:

(a) Climate: Oceans influence the distribution of temperature and humidity over the earth's surface.

(b) Source of energy: Tidal force, differences in oceanic temperatures, and geothermal energy are great source of energy.

Oceans: regulators and stabilizers of earth's climate

Water not only heats up slowly than land but also cools much more slowly than land. The enormous absorbing and liberating capacities of the oceans do not allow extreme temperature on the coastal areas and over the surface of the earth. Ocean currents also help in modifying the distribution of temperature along the coastal areas. The oceans are the main source from which our atmosphere derives its moisture and gives rain. Thus, the oceans are great regulators and stabilisers of climatic phenomena over the earth's surface.

The major commercial fishing grounds of the world:

Five major commercial fishing regions have been identified:

(a) North American waters.

(b) North West European waters.

(c) South American waters.

(d) North East Asian waters.

(e) East Indian waters.

Important minerals found in the oceans:

Oceans are storehouse of large number of minerals. Mineral occur both in solution and in suspension.

Minerals found in solution are dissolved salts that are common in sea water such as common salt, magnesium and bromine.

Other minerals such as petroleum, natural gas, manganese, phosphorite, sulphur, titanium, zircon, monazite, gold, platinum, diamonds, tin, iron, sand, gravel and others, are also found in the oceans.

Ocean and International Trade:

The oceans provide the most important means of natural transport to man. It is the easiest and cheapest one. No road or railway line needs to be constructed. Oceans no more divide continents but provide natural links between them. They are the natural highways for trade.

Countries that have successfully harnessed the tidal forces: Russia, France and Japan.

Pelagic: The open ocean environment.

Plankton: Floaters which have no means of reef propulsion.

Necktons: Swimming organisms of the aquatic environment.

Benthos: The organisms that live on the ocean floor.

Coral: It is kind of calcareous rock made of the skeletons of minute sea organisms, called polyp.

Fringing Reef: It is a coral platform attached to the coast of a continent.

Terrigenous deposits: The deposits that have been derived from land but subsequently mixed in with marine deposits of the littoral zone.

Pelagic deposits: The deep sea sediments unaffected by land derived material and derived mainly from the remains of pelagic marine organisms.

Ooze: Fine textured sediment formed on the ocean basins at depths greater than 2000 metres.

Red Clay: An ocean floor deposit of the abyssal zone. It is derived from a combination of volcanic ash, meteoric dust etc.

Diatoms: Single celled microscopic algae covered with silicon shell.

Dinoflagellates: Unicellular, microscopic algae having two flagella for locomotion.

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