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OCEANOGRAPHY

Oceanography is the study of the shape, size, depth and bottom relief of ocean, distribution of oceans, ocean currents and various life forms existing in ocean.

Oceans and Seas:

- The term ocean takes its origin from the Greek word '**Oceaonus**' meaning enormous river encircling the earth. The area of the World Ocean is 361 million sq.km.
- Geoscientists believe that the oceans were formed on Earth nearly three billion years ago. It is difficult to believe that in the beginning there was no water on our planet. In due course of time, when the Earth started cooling, steam escaped from the interior and entered the atmosphere to form clouds.
- At first, the clouds brought incessant rains. The rain water filled the depressions for tens of thousands of years and eventually a super ocean was formed.
- The continents and oceans are however, not evenly distributed in the northern and the southern hemispheres. The northern hemisphere holds 61% of land whereas the southern hemisphere holds 81% of water.
- It is because of this pattern of land and water distribution; the **northern hemisphere** is called as the **land hemisphere** and the **southern hemisphere** is called as the **water hemisphere**.
- The water in the oceans and seas is termed as marine water. Continuous water body that surrounds the continents, created by earth's internal force is known as Ocean.

The earth has at present five major oceans:

The Pacific Ocean, the Atlantic Ocean, the Indian Ocean, the Arctic Ocean, and the Southern Ocean. All these oceans are inter connected to form one **Global Ocean** or

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World Ocean. This nature of water to level up quickly has made it as a reference point to measure the height of the land features and the depth of the sea features.

Sea is a body of saline water (generally division of the world ocean) partly or fully enclosed by land.

Marginal sea is a sea partially enclosed by islands, archipelagos, or peninsulas and extension of oceans towards land. They are generally shallow. Andaman Sea, Arabian Sea, Bay of Bengal, Java Sea, Persian Gulf and Red Sea are marginal seas of the Indian Ocean.

Bay is a water body surrounded on three sides by land and the fourth side (mouth) wide open towards an ocean.

Gulf is a large body of water, with a narrow mouth, that is almost completely surrounded by land. The world's largest gulf is the Gulf of Mexico. **Sound, creek, bight** and **cove** are bays which vary in size and depth.

Strait is a narrow channel of water, connecting two larger bodies of water. Palk Strait connects Gulf of Mannar and Bay of Bengal.

Isthmus is a narrow strip of land connecting two larger landmasses. Isthmus of Suez connects Africa and Asia.

Enclosed seas are seas that reach very deep into the continent stay connected with one or the other ocean of the world through straits. Mediterranean Sea is the best example for enclosed sea.

Partly Enclosed Seas are those types of seas that are connected to the oceans by a very wide opening and have similar characters of the adjacent ocean. A series of islands may also occur between a partly enclosed sea and the ocean to which it is connected. Caribbean Sea is a perfect example.

Landlocked Seas are completely surrounded by landmass on all sides without any natural outlet. They are actually hyper saline lakes. Dead Sea and Caspian Sea are good examples of landlocked seas. Jordan River and Volga River flow into Dead Sea and Caspian Sea respectively.



Fjord is a long-indented bay with steep slope that has been created by the submergence of U-shaped glacial valley. Example: Sogne Fjord in Norway (203 km).

Ria is an indented bay with gradual slope formed by the submergence of V shaped river valley. George River in Sydney is the best example for Ria.

Maritime zones:

The low-tide line forms the base line for marking maritime zones. Water landward of the baseline is defined as **internal waters** over which the state has complete sovereignty. A country's **territorial sea** extends up to 12 nautical miles (22.2 km) from its baseline. The **contiguous zone** is a zone of water extending from the outer edge of the territorial sea up to 24 nautical miles (44.4 km) from the baseline. An **Exclusive Economic Zone (EEZ)** extends from the base line to a maximum of 200 nautical miles (370.4 km). A coastal nation has control of all economic resources within its exclusive economic zone, including fishing, mining and oil exploration. Everything beyond EEZ is called **International Waters or the High Seas**. No nation has sovereign rights over this area.

Nautical mile - A nautical mile is based on the circumference of the earth, and is equal to one minute of latitude which is equivalent to one sixtieth of a degree of latitude. A nautical mile is a unit of measurement defined as 1,852 metres. Nautical miles are used in Navigational charts.

Relief of ocean:

The bottom of the ocean has a variety of land forms just as it is seen on the earth's surface. There are large mountain ridges, deep depressions, flat plains, basins and volcanoes. The configuration of an ocean floor is shown with the help of a '**Hypsometric curve**' or '**Hypsographic curve**'. It is a graph denoting the proportion of a landmass standing above or below the sea level.

◆.....◆ **Continental shelf:**

- Continental shelf is the seaward extension of land that lies under the sea water. It occupies 7% of the sea floor. The continental shelf slopes gently away from the land and is covered with shallow seas with an average depth of 200 fathoms.
- The width of the continental shelf varies according to the nature of the rock beneath the crust. If the crust is dynamic then the shelf would be narrow and vice versa.
- Continental shelves are formed due to either any one or combination of the factors like fluvial deposits, marine erosion, tectonic forces, and the fluctuations in sea level in the past. Continental shelves are well known for oil, natural gas, mineral deposits and coral reefs. World famous fishing grounds like Grand Bank are situated here.
- The world's widest continental shelf (1210 km long) is located along the coast of Siberia, in Russia. Continental shelf on the east coast of India is formed by deltas of the Ganga, the Godavari, the Krishna and the Cauvery. On the West coast of India, the continental shelves are formed due to faulting and consequent submergence.

Continental Slope:

- The zone of steep slope extending from the continental shelf to the deep sea plain or abyssal plain is called continental slope. The slope angle varies from 5° to 60°. It occupies 9% of sea floor.
- This is the region in oceans where landslides, turbid currents, large sediments lumps, under water canyons, gorges cut by the currents and rivers occur. The deposit from the continental shelves immediately falls down here. The origin of continental slope is believed to be due to erosional, tectonic and aggregational processes.

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Continental rise:

The area between the continental slope and the sea floor is known as the continental rise. This part is noted for the accumulation of sediments similar to the alluvial fans near the foot hills in the land. It represents the boundary between continents and abyssal plain. It constitutes about 5% of the oceanic area.

Abyssal plain:

The Abyssal plain is the vast area of flatter rain in the bottom of the oceans. It is the largest part of ocean relief covering more than 50% of the total area. There is an accumulation of very fine sediments on the floor. The sediments are combinations of fine particles of clay and microorganisms. As in the case of sedimentary rocks of earth's surface these sediments are in layers and reused to trace geological events in the past.

Mid oceanic ridges:

The mid-ocean ridges are submarine mountains. They are continuous and are connected to form a single global mid oceanic ridge system. They are formed by the tectonic forces acting from within the earth.

Mid oceanic ridges are located on the divergent plate boundaries where magma flows through the fissure to form new oceanic crust. They form the longest mountain range in the world extending for more than 56,000 km long and has a maximum width of 800–1,500 km.

Ocean trench:

- The long, narrow, steep-sided depressions formed by tectonic forces beneath the abyssal plain are called Ocean trenches. Oceanic trenches actually extend 3 to 4 km below the level of the abyssal plain.
- There are 26 oceanic trenches in the world: 22 in the Pacific Ocean, 3 in the Atlantic Ocean and only one in the Indian Ocean.
- The Challenger Deep in the Mariana Trench, (10,994 m) in the Pacific Ocean is the deepest part of the earth. A trench forms along the convergent boundary where one plate subducts below the other

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Island:

An island is a landmass surrounded by water on all sides. Islands may be formed on the continental shelf or as oceanic islands. Most of the oceanic islands are volcanic in origin. Group of islands formed by subduction of ocean plate are known as **archipelago**. Islands of Japan form an archipelago. Marine organisms, the coral polyps colonize the tropical warm water and form islands known as **coral islands**. Lakshadweep Island in Indian Territory is made of corals. Andaman Nicobar Islands are of volcanic origin.

Guyots:

Flat topped volcanic hills submerged under the sea water are called **guyots**. It is a part of an underwater chain of volcanic mountains produced by slow plate movement.

Seamounts:

Seamounts are conical, volcanic hills submerged under ocean water. It does not reach to the water's surface. It is an isolated rise with an elevation of thousand metres or more from the surrounding seafloor and with a limited summit area. It occupies 4.39 percent of ocean region. Seamounts and guyots are most abundant in the North Pacific Ocean.

Ocean Temperature

The measurement of degree of hotness or coldness of ocean water is referred to as ocean temperature. Temperature is normally measured in the unit of degree Celsius by thermometers. The major source of heat energy for ocean water is the radiation from sun. The heating and cooling capacity of water differs significantly from that of land.

Factors affecting horizontal distribution of ocean temperature

The factors affecting distribution of ocean temperature are latitude, prevailing winds, ocean currents and local weather.

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Latitude:

The temperature of surface water decreases from equator towards the poles because of the slanting rays of the Sun pole ward.

Prevailing wind:

Direction of the wind affects the distribution of temperature of ocean water. The off shore winds blowing from the land towards ocean or sea raise the temperature of ocean water. Winds blowing from snow covered regions in winter lower the surface temperature. In trade wind belt, the off shore winds initiate upwelling of cooler water from beneath and on shore winds pile up warm water to increase the temperature to certain extent.

Ocean currents:

Warm currents raise the temperature of the oceans where they flow whereas cold current slower down the temperature. Gulf Stream (warm current) increases the temperature of the eastern part of North America and the west coast of Europe. Labrador cold current reduces the temperature near north eastern coast of North America.

Apart from these, some minor factors like submarine ridges, local weather conditions like storms, cyclones, hurricanes, fog, cloudiness, evaporation and condensation also affect the surface temperature of ocean water.

Vertical distribution of temperature in oceans

- The uppermost layer of ocean water is warm and well mixed surface layer with average temperature between 20° and 25°C. The depth of this layer varies according to seasons.
- On an average this layer extends up to 200 m in tropical region. Beneath this layer lies the thermocline layer. This layer varies in depth between 200 m to 1000 m.

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- This layer is unique that the temperature decreases rapidly with increasing depth. Below the thermocline temperature decrease is gradual up to 4000 m.
 - Beneath this depth the temperature of ocean water is constant at 4°C.

Salinity of the ocean:

Salinity is defined as the ratio between the weights of dissolved salts (in grams) per 1000 grams of water. It is expressed as part per thousand (‰) and has no units. Example: 30‰ means 30 grams in 1,000 grams of sea water. The average ocean salinity is 35‰.

Sources of salt in the ocean:

- Sea water is a weak but complex solution made up of many things including mineral salts and decayed biological marine organisms. Most of the ocean salts are derived from weathering and erosion of the earth's crust by the rivers.
- Some of the ocean salts have been dissolved from rocks and sediments below the sea floor, while others have escaped from the earth's crust through volcanic vents as solid and gaseous materials.

Factors affecting the salinity of oceanwater

The salinity of ocean water depends upon,

- The rate of evaporation
- Amount of precipitation,
- Addition of fresh water flow from rivers
- Ice in Polar Regions
- Upwelling of deep water initiated by prevailing winds and
- Mixing of water by ocean currents.

Distribution of salinity

- On an average the salinity decreases from equator towards the poles. The highest salinity is observed between 20° and 40° north latitudes because this zone is

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characterized by high temperature, high evaporation but less rain than the equatorial region.

- The marginal areas of the oceans bordering the continents have lower salinity than their interior due to addition of fresh water to the marginal areas through the rivers. Very high salinity is recorded in Lake Von, Turkey (330‰) Dead Sea (238‰)and Great Salt Lake, Utah, USA (220‰).

Marine Resources:

1. Marine biome is an aquatic biome which is salt water biome occupying seas and oceans of the world. Marine biome plants have various roles, plants such as sea grasses and macroalgae give shelter and nutrient for many animals.
2. Marine plants are sources of nutrients for the corals and help corals to build up reefs. The reefs are kept intact by plants like coralline algae.
3. Corals are marine invertebrates which live in compact colonies. They inhabit tropical oceans and seas. Corals cannot survive in waters below 20°C but grow optimally in temperatures between 23°–29° Celsius. Coral reefs are marine ecosystems which are held together by structures made of calcium carbonate secreted by the corals.
4. Coral reefs are mainly classified into three types –
 - Fringing reef,
 - Barrier reef
 - Atoll.

Fringing reefs grow seaward from the shore along the coast forming a fringe. They are the common type of reefs.

Barrier reefs also border the shoreline but are separated from the coast by an expanse of water or lagoon.

Atolls are coral reefs that are circular in shape enclosing a lagoon with absence of an island in the center.

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Marine biome includes fishes, whales, crustaceans, molluscs, sea anemones, fungi and bacteria. Marine species are continuously impacted by change in climatic condition and the oceans are frequently disturbed by ocean waves and currents.

Bottom relief features of Indian Ocean, Arabian sea and Bay of Bengal

Introduction:

1. The Indian Ocean is smaller than the Pacific and Atlantic Ocean in areal extent and is bounded by, on all of its sides, Asia in the north, Africa in the west, Asia in the east, Australia in the south-east and Antarctica in the south.
2. The ocean has contact with the Pacific and the Atlantic oceans in the south near Antarctica. The average depth of the ocean is 4000 m. Major parts of the coastal lands of the Indian Ocean formed by the block mountains of Gondwanaland are compact and solid. The coasts of the East Indies are bordered by fold mountain chains.
3. The marginal seas are less in number than the Pacific and the Atlantic oceans. Significant marginal seas are Mozambique Channel, Red Sea, Persian Gulf, Andaman Sea, Arabian Sea, Bay of Bengal etc. Malgasy (Madagascar) and Sri Lanka are the big islands whereas Suputra, Zanzibar, Comoro, Reunion, Seychelles. Prince Edwards, Crozet, Kerguelen, St. Paul Rodriguez, Maldives, Laccadive, Andaman-Nicobar Christmas etc. belong to the category of small and tiny islands.
4. Indian subcontinent in the north divides the Indian Ocean into Arabian Sea and Bay of Bengal. The ocean widens in the south.

Continental Shelf

There is wide range of variation in the continental shelves of the Indian Ocean. Quite extensive shelves are found along the margins of Arabian Sea and Bay of Bengal. Similarly, extensive shelves are observed along the eastern coast of Africa and around Madagascar which is itself located on the continental shelves. On an average, the continental shelves are very wide (640 km) in the west whereas these are narrow (160

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km) along the coast of Java and Sumatra. These become further narrow along the northern coast of Antarctica.

Mid-Oceanic Ridge

- The central ridge or mid-oceanic ridge known as Mid-Indian Oceanic Ridge extends from the southern tip of Indian Peninsula in the north to Antarctica in the south almost in north south direction and forms a continuous chain of highlands. Wherever the central ridge or its branches emerge above the sea level, islands are formed.
- The main central ridge starts from the continental shelf of the southern tip of Indian Peninsula with average width of 320 km. This part of the ridge is known as Laccadive-Chagos Ridge (also known as Maldiva Ridge). The ridge further extends southward and widens near equator. It is called Chagos-St. Paul Ridge between equator and 30°S latitude where the average width becomes 320 km. The ridge further widens to 1,600 km between 30°S and 50°S latitudes and is known as Amsterdam-St Paul Plateau.
- The central ridge bifurcates to the south of 50°S latitude. The western branch known as Kerguelen-Gaussberg ridge extends in NW-SE direction between 48°S and 63°S and the eastern branch is known as Indian Antarctic Ridge.

Ocean Basins

The mid-Indian Oceanic Ridge divides the Indian Ocean into two major basins-the eastern and the western basins. These basins are further divided into sub-basins by the branches of the central ridge.

1. Oman basin faces the Gulf of Oman and is spread over the extensive continental shelf with average depth of 3,658 m.
2. Arabian basin is located in almost circular shape between Laccadive Chagos ridge and Socotra - Chagos Ridge with the depth of 3,600 m-5,486 m.

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3. Somali basin is bordered by Socotra- Chagos ridge in the north-west, Central Ridge in the east, Seychelles- Mauritius Ridge in the south-west and African coast in the west, the average depth is 3,600 m.
 4. Mauritius basin is located between S.W. Indian Ridge and South Madagascar Ridge and extends from 20°S to 40°S latitude. The depth varies between 3,600 m and 5,486 m. The deepest part measures 6,391 m depth.
 5. Mascarene basin of oval shape extends between Madagascar and Seychelles - Mauritius Ridge.
 6. Agulhas-Natal basin is an elongated basin which is bordered by Madagascar ridge in the north and north-east, Prince Edward Crozet Ridge in the east and the S.E. African coast in the west and north west. Average depth is 3,600m,
 7. Atlantic-Indian Antarctic basin is in fact the eastward continuation of Atlantic-Antarctic Basin. It stretches upto 70°E longitude and is bordered by Prince Edward Crozet Ridge in the north, Antarctica in the south and Kerguelen Glassberg Ridge in the north-east. Average depth is 3,600 m,
 8. Eastern Indian-Antarctic basin is located between Amsterdam- St. Paul Plateau and Indian-Antarctic Ridge in the north and north-east and Antarctica in the south. The depth varies from 3,600 m to 4,800 m. Kerguelen-Glassberg Ridge separates the basin from the Atlantic-Indian Antarctic Basin.
 9. West Australian basin is the most extensive basin and forms rectangular shape surrounded by S.E. Indian Ridge in the south- west, Ninety East Ridge in the west, continental shelves of Java-Sumatra in the north-east and the continental shelves of west Australia, Average depth varies from 3,600 m to 6,100 m but the central part of the basin is 6,459 m deep.
 10. Mid-Indian basin is bordered by the central ridge in the west and the south-west, by Ninety East Ridge in the east and by the Bengal plateau in the north. The average depth of outer part ranges from 3,600 m to 6,800 m while the depth of the central part of the basin ranges between 4,800 m and 6,100 m.

◆.....◆ **Deeps and Trenches**

There are very few deeps and trenches in the Indian Ocean. About 60 per cent of the Ocean consists of deep-sea plains with depth ranging from 3,600 m to 5,487 m. Important deep-sea plains are Somali Abyssal plain. Ceylon (Sri Lanka) Abyssal plain, Indian Abyssal Plain, (4,380 m) etc. Significant trenches are Java or Sunda Trench (7,450 m deep), Ob Trench (6,875 m deep), Mauritius Trench, Amirante Trench etc.

Questions

1. Explain about the relief of oceans.
2. Elucidate the salinity of the ocean and its distribution.
3. Discuss about the bottom relief features of Arabian sea & Bay of Bengal.

