11th Geography Lesson 3 Notes in English

3. Hydrosphere

Introduction

"World cannot survive without water and morality cannot exist without rain"

"நீர்இன்று அமையாது உலகெனின் யார்யார்க்கும்
வான்இன்று அமையாது ஒழுக்கு"

- As **thirukkural** quotes, water is the most important resource in the world.
- Over 90% of the world's supply of **fresh water** is in **Antarctica**.
- You must know that 85% of the world population lives in the driest half of the planet. Now we shall learn about the **hydrosphere** in detail.
- Water is the most common substance found on earth.

- It is an important constituent of all life forms on the earth.
- Hydrosphere is one among the **four spheres of the earth**.
- The hydrosphere includes **the water on the surface of the earth**, the water below the surface called ground water and the water in the atmosphere above earth's surface.
- Oceans, rivers, lakes and glaciers form part of surface water.
- There is substantial amount of water under the surface of the earth.
- The atmosphere has **water** in all **the three forms**.
- The total amount of water on the earth does not change over time.
- Water is constantly in motion within the spheres of the earth which is being transformed and reused all over the earth. The earth's hydrosphere, thus, acts as a closed system.

Distribution of Land and Water in the Earth

- Earth is covered by **land** and **water**.

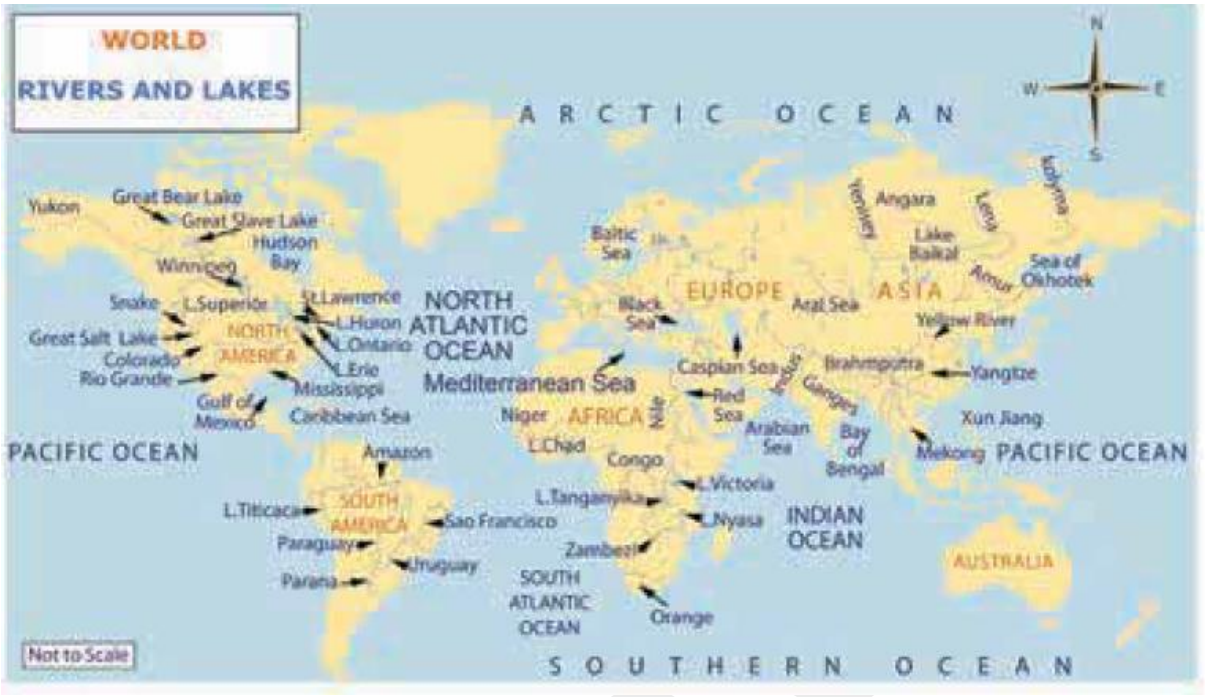
- About **70.8% of its area** (361million sq km) is covered by **water** and **29.2%** (148 million sq km) of its area by **land**.
- About **96.5% of water is salty** found in seas and oceans.
- **Fresh water** occupies only **2.5%. Saline ground water** and **saline lakes** together form **1%.**

Fresh water

- **Fresh water** is defined as water with a **salinity of less than1%** compared to that of the oceans (i.e. below 0.35%).
- **Water** with **salinity** between **0.35‰ and 1‰** is typically referred to as **marginal water** because it is marginal for many uses by humans and animals.
- Considering the distribution of **fresh water 68.6%** of it is locked in **Glaciers** and **icecaps**.
- About **30.1% is stored as ground water** and the remaining **1.5%** is available as **surface water**.
- Surface water includes ice and snow on the land and sea, water in the lakes, rivers, swamps and marshes, moisture in soil, atmosphere and biosphere.
- Rivers and lakes are the major sources of fresh water around the world, and are vital to the communities they serve.

Rivers:

- Rivers generally have a source on a mountain either from a glacier, a spring or a lake.
- **River Ganga** has its source from **Gangotri glacier** in the **Himalayas**.
- **River Cauvery** has its source from a spring in **Talacauvery** located in **Kodagu** district of **Karnataka**.
- **River Nile** has its source near **Lake Victoria** in **Uganda**.
- The river flows through confined channel between two banks and ends up at the mouth which is either on a sea or lake.
- When rivers drain their water into a lake or an inland sea, it is said to be an **inland drainage.**
- The **Nile River** in **Africa** is the **longest river** in the **world**.
- The Nile River flows through Egypt, Uganda, Ethiopia, Kenya, Tanzania, Democratic Republic of the Congo, Rwanda, Burundi, Sudan and Eritrea drains and into the Mediterranean Sea forming a delta to the north of Cairo city.
- The river **Amazon** in **South America**, is the **second longest river**, and has the largest drainage basin of any river.
- The Amazon River flows through Peru, Colombia, and Brazil and drains into the Atlantic Ocean forming **an estuarine delta**.



RIVERS AND LAKES

- **The Yangtze River**, which flows in **China**, is the **longest river in Asia**, and the **third longest river** in the **world**.
- The longest river system in **the United States**, **the Mississippi-Missouri system** is considered **the fourth longest river** in the world.
- The total **volume of water** in rivers in the world is estimated at **2,120 km cube.**
- Asia excluding **Middle East**, has the largest run off of **13,300 km3/year** followed by **North America** with **12,000 km3 per year**.

Lakes:

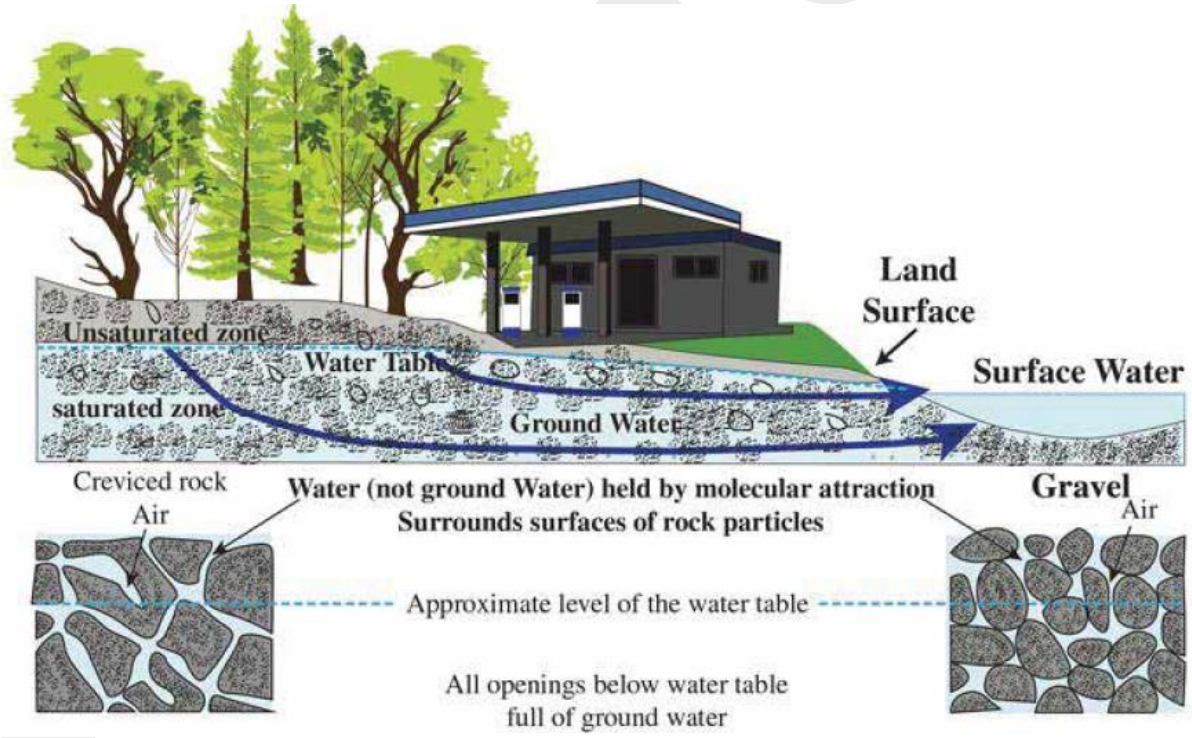
- Lakes are **larger bodies of water** with outlet through a river or stream.
- Lakes may have their origin through tectonic activity, volcanic activity, river, glacier and wave action or sometimes meteoric origin.
- **Caspian Sea**, **Lake Baikal** and **Wular Lake** have been formed by **earth movements**.
- **Lake Baikal** is the **deepest freshwater lake** in the **world**.
- **Caspian Sea** is the **largest salt water lake** in the **world**.
- **Lagoon lakes** are formed by **wave deposition**.
- **Chilika lake** is the **largest lagoon lake** in India.
- **Lonar lake** in **Maharashtra** is believed to be formed by depression created by **meteor** impact which hit during **Pleistocene Epoch.**

Wetlands

- Wetlands are areas of **marshy, fen, peat land** or **water** that is static or flowing, fresh, brackish or salt, including areas of **marine water** the depth of which the low tide does not exceed the six meters.
- Marshes are **swallow wetlands** around lakes, streams, or the ocean where grasses are reeds are common, without trees.
- **Rann of Kutch** in India is a **salt marsh**.
- A swamp is a wetland with **lush trees** and **vines** found in low lying area beside slow-moving rivers.
- **Pallikaranai wetland** is a fresh water swamp adjacent to the Bay of Bengal situated in the **Southern part of Chennai**.

Groundwater

- Groundwater is the **most valuable resource** for any country.
- **The rain water** that **falls** on the earth earlier runs off as surface water or precolates into the ground to **recharge the ground water**.



GROUND WATER

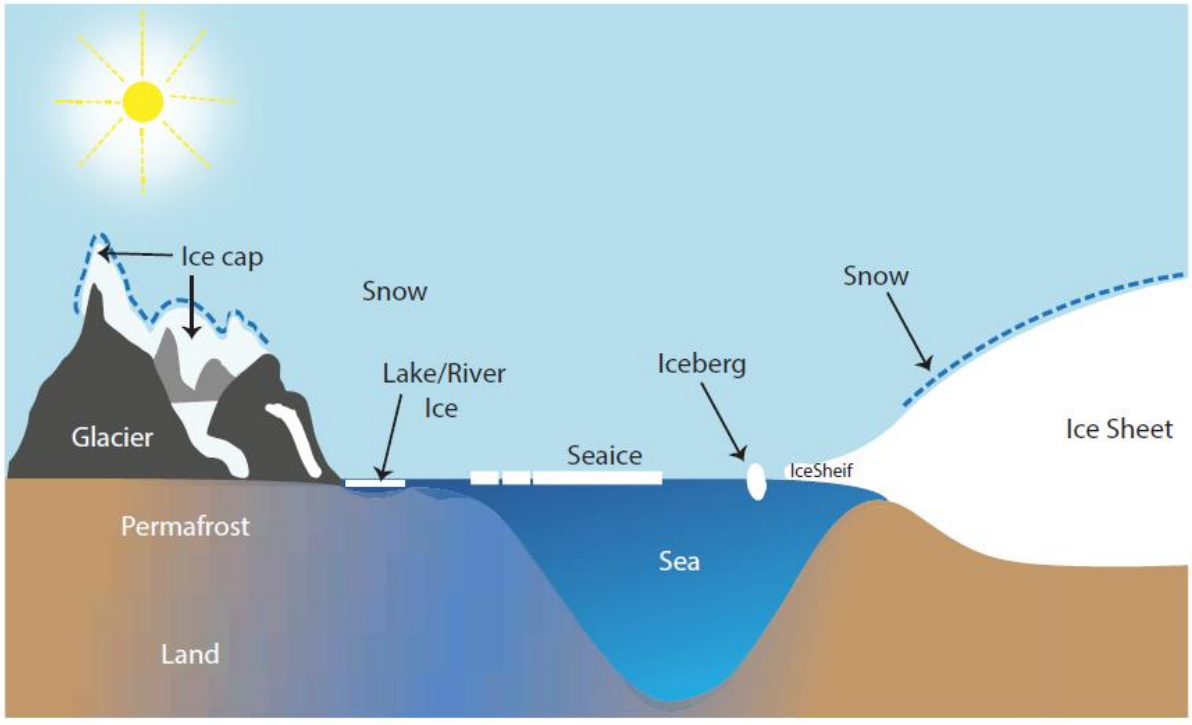
- The permeable rocks that can hold water and allow water to pass through them are called **aquifers**.
- The upper part of the saturated zone of the aquifer is called the water table.
- The level of the **water table** fluctuates according to the season.

Fact File

- **Tmc ft,** is the abbreviation for **one thousand million cubic feet** (1,000,000,000 = 1 billion), commonly used in **India** with reference to **volume of water in a reservoir** or **river flow.**

Cryosphere

- Cryosphere includes the **water** in **frozen** state.
- Glaciers, ice sheets, ice caps, lake and river ice, permafrost, seasonal snow and ice crystals in the atmosphere together form **cryosphere**.
- Earth's climate is highly influenced by the extent of cryosphere as it controls the energy budget of the **earth Perennial ice cover** is found in **Greenland** and **Antarctica** as ice sheets, as mountain glaciers and as permafrost in **higher latitudes**.
- **Permafrost** is the condition prevailing when water freezes above and below the ground, (including rock or soil) for more than two consecutive years.
- Most permafrost regions are located in high latitudes, but **alpine permafrost** may exist at high mountains in much **lower latitudes**.



CYROSPHERE

Fact File

- **Mount Kilimanjaro** (5895m) in Tanzania, Africa, located closer to the equator has permafrost.
- Seasonal snow and ice crystals are confined to **middle latitudes** and high mountains in lower latitude.

- **Sea ice** is frozen ocean water. Its formation, growth and melting are all confined to the ocean.
- **An ice shelf** is a thick, floating slab of ice that forms where a glacier or ice flows down a coastline.
- The world's largest ice shelves are **the Ross Ice Shelf** and the **Filchner-Ronne ice shelf** in Antarctica.
- **An iceberg** is ice floating in open water that has broken off from glaciers or ice shelf.

Interaction of cryosphere with other spheres

- Cryosphere is a **climate indicator**.
- Cryosphere with its high **albedo** influences the energy balance of the whole planet.
- Changes in **cryosphere** will **alter** land cover, surface temperature, soil moisture, air temperature, radiation, air circulation, clouds, precipitation, sea level, sea surface temperature, salinity, ocean current, fauna, flora and microbes.
- There is a complex **interaction** and **balance** among the **spheres of the earth** which makes life to flourish in the earth.
- If there is a change in one sphere it affects the other spheres as well.
- **Nature** maintains this balance.
- Understanding this complex interactions and living in harmony with nature will help to mitigate the environmental **problems** faced by **the earth**.

Oceans and Seas

- 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 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 square kilometre.
- 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 interconnected to form one **Global Ocean** or **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.

Fact File

- **Mean Sea Level** (MSL) is the average height of the surface of the sea for all stages of the tide.
- MSL is reference point to measure the **height of land** features and **depth** of the **sea** features.

Sea

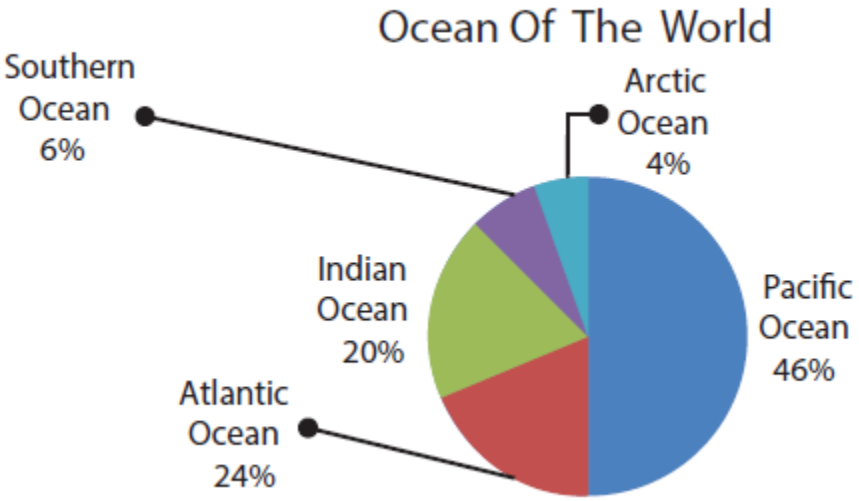
- Sea is a body of **saline water** (generally a division of the world ocean) partly or fully enclosed by land.
- **Marginal sea** is a sea partially enclosed by islands, archipelagos, or peninsulas and extension of oceans towards land.
- They are generally **shallow**.
- Andaman Sea, Arabian Sea, Bay 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 land masses.
- 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.
- **6Landlocked 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.
- **Jordon 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.

Oceans of the world

1. The Pacific Ocean

- Pacific Ocean is the **largest ocean in the world**. It is bigger than all continents put together.

- Portuguese explorer **Ferdinand Magellan** in 1521 named the ocean Pacific Ocean meaning **'peaceful'** because he felt the ocean to be calm after sailing from the Atlantic Ocean through the stormy and dangerous **Strait of Magellan**.
- Average depth of this ocean is **4,280 meters**.



DISTRIBUTION OF THE OCEANS

2. The Atlantic Ocean

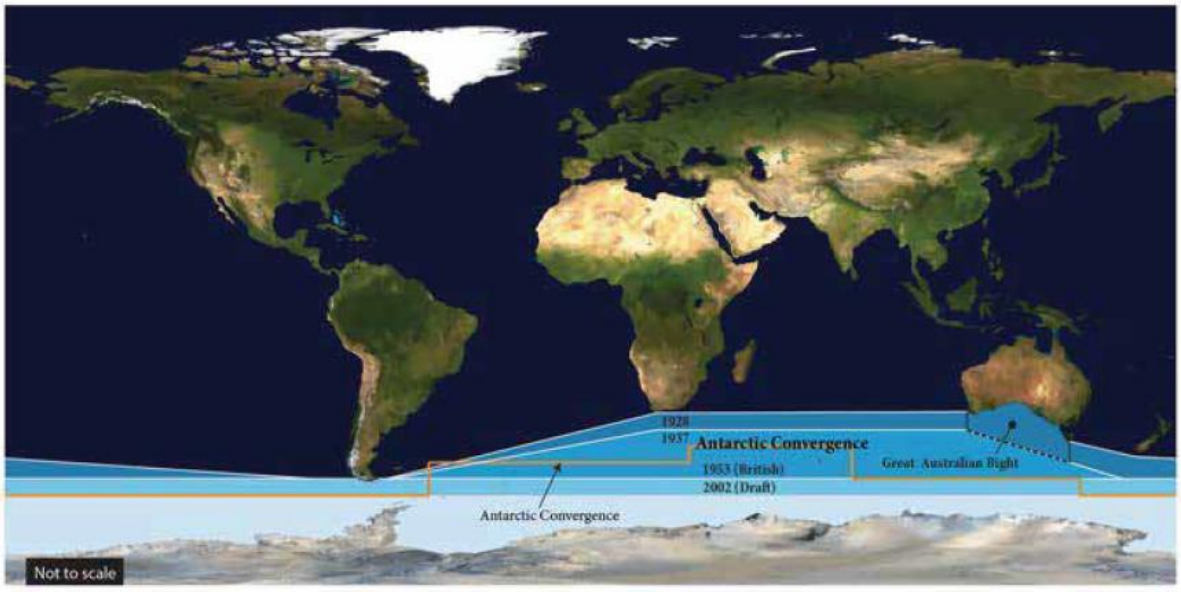
- Atlantic Ocean is the **second largest ocean of the world**. The Atlantic Ocean's name refers to **Atlas of Greek** mythology.
- The **North Atlantic Ocean** was formed by the break-up of the supercontinent **Pangaea** and the **south Atlantic** was formed when **the Gondwana** land broke in the geological past.

Fact File

- **The Suez Canal**, an artificial sea level waterway in Egypt, connecting the **Mediterranean Sea** to **the Red Sea** through the **Isthmus of Suez** was officially opened on November 17, 1869.

3. The Indian Ocean

- The Indian Ocean is the **third-largest ocean in the world**.
- It is named after **India**.
- Its calm open water has encouraged the **sea trade** earlier than the Atlantic of the Pacific Ocean.



Antarctic convergence

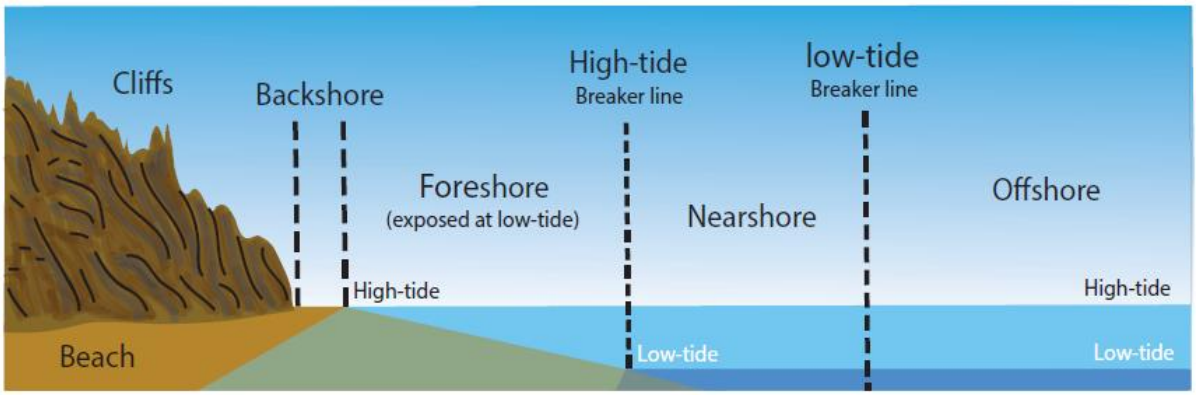
[1953 –British, 2002-Draft, Great Australian Bight]

4. The Southern Ocean

- The Southern Ocean is the **world's fourth-largest ocean**.
- The Southern Ocean is the **youngest ocean** and formed 30 million years ago when **the South America** moved from the Antartica, opening the **drake Passage**.
- This ocean has the boundary where cold, northward flowing water from the **Antartica** mixes the warmer **sub Antartica water**.
- During summer in **southern hemisphere** over half of the southern ocean is covered with **ice** and **icebergs**.

5. The Arctic Ocean

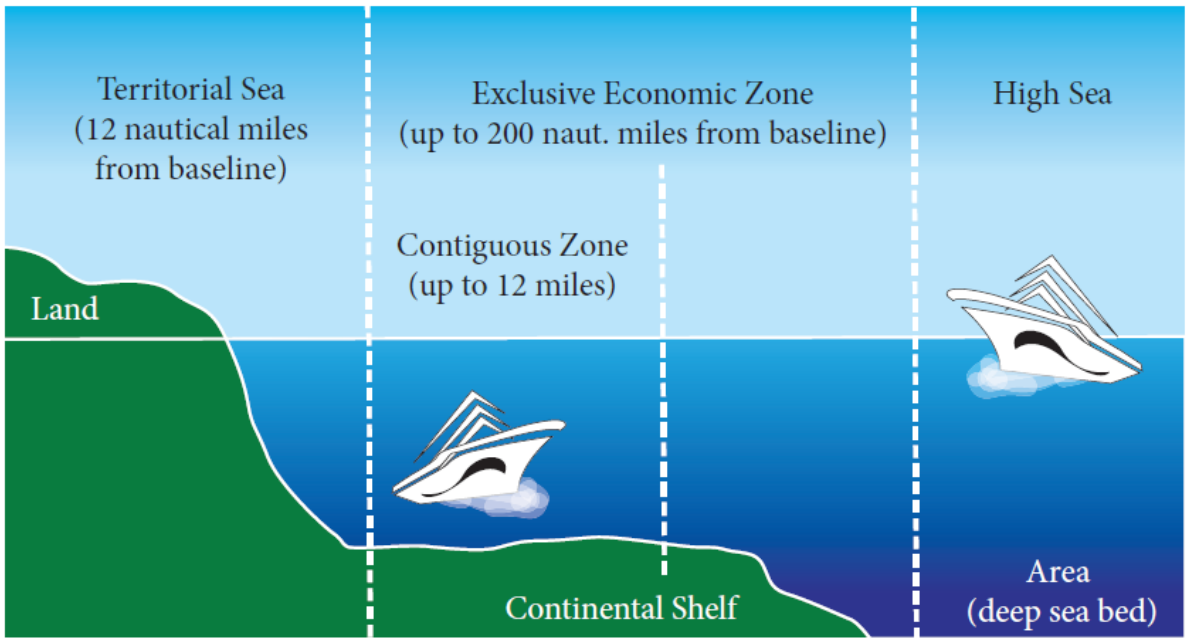
- The Arctic Ocean is **shallower** and **smaller** than the other oceans.
- It is completely surrounded by **Eurasia** and **North America.**
- It is covered by the **ice** completely in the winter.
- The Arctic Ocean's surface temperature and the salinity vary seasonally as the ice cover melts and freezes alternatively.



- Its **salinity** is the **lowest** on an average of the five major oceans.
- **Bering Strait** connects the Arctic Ocean with the Pacific Ocean while the Greenland Sea and the **Labrador Sea** connects it with the Atlantic.
- The deepest point in **Litke Deep** in the **Eurasian Basin**, or 5,450 m.
- The **International Hydrographic Organisation** (IHO) is the inter-governmental organisation that surveys and produces charts for the world's sea, oceans and navigable waters

Maritime zones

- The **low-tide line** forms the base line for marking **maritime zones**.
- Water landward of the baseline in 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.



Maritime Zones

- **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.

Fact File

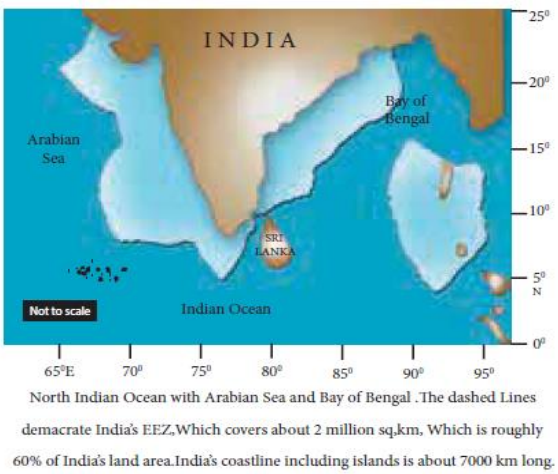
- **A nautical mile** is based on the circumference of the earth, and is equal to one minute of latitude which is equivalent to **one sixtieth of a degree of latitude**.
- A nautical mile is a unit of measurement defined as **1,852 metres.**
- Nautical miles are used in **Navigational charts**.

Relief of ocean

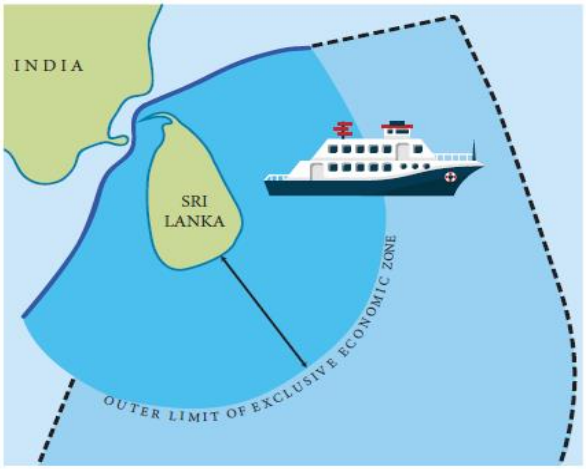
- **The bottom of the ocean** has a variety of landforms just as it is seen on the earth's surface.
- There are large mountain ridges, deep depressions, flat plains, basins and volcanoes.
- The configuration of an ocean floor is shown with the help of a **'Hypsometric curve'** or **'Hypsographic curve'.**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

Indian National Centre for Ocean

- Information Services (**INCOIS**) with its **Marine Satellite Information Services** uses the remotely sensed sea surface temperature (**SST**) to identify the locations of fish aggregation.
- The details of the **Potential Fishing Zones** (PFZ) are then disseminated to the fishermen once in every three days along the **Indian Coast** by displaying the details in the Lighthouse in their respective regional language.



North Indian Ocean with Arabian Sea and Bay of Bengal .The dashed Lines demacrate India's EEZ,Which covers about 2 million sq.km, Which is roughly 60% of India's land area.India's coastline including islands is about 7000 km long.



India's Exclusive Economic Ocean

[North Indian Ocean with Arabian Sea and Bay of Bengal, The dashed lines democratic India's EEZ, which covers about 2 million sq.km . Which is roughly 60% of India's land area India's coastline including islands is about 7000 km long]

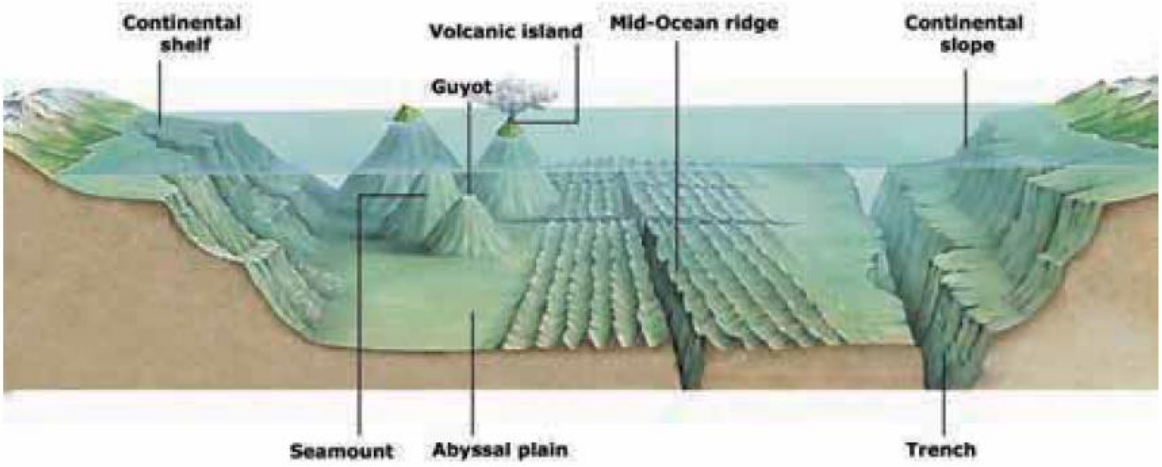
Continental shelf

- 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 sediment slumps, 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 **aggradational processes**.



MAJOR RELIEF FEATURES OF OCEAN FLOOR

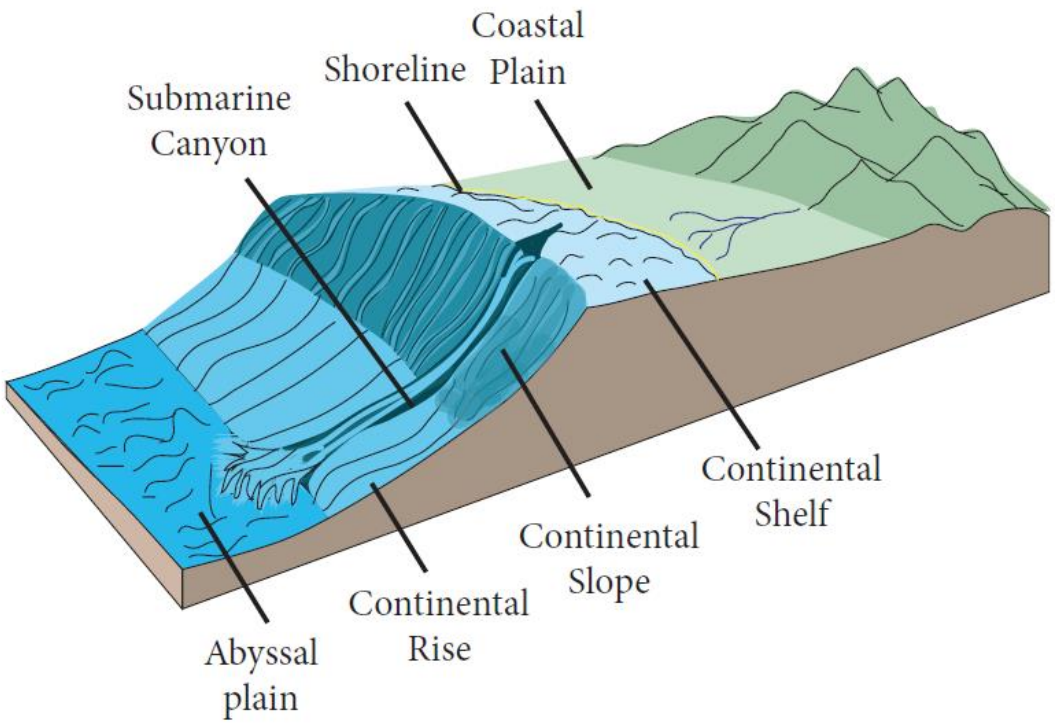
[Continental Shelf, Seamount, Abyssal plain, Guyot, Volcanic island, Mid-Ocean ridge, Continental Slope, Trench]

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 **flat terrain** 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 are used to trace geological events in the past.



Ocean relief

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.

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**.

Major Ocean Trenches of the world

Name of the Trench	Location	Depth (in Metres)
Challenger in Mariana Trench	North Pacific	10,994
Aldrich or Tonga Trench	South Pacific	10,882
Kurile Trench	North Pacific	10,554
Tizar Romanche Trench	South Atlantic	7,761
Sunda Trench	East of Indian Ocean	7,450

Source: Geology.com

Fact File

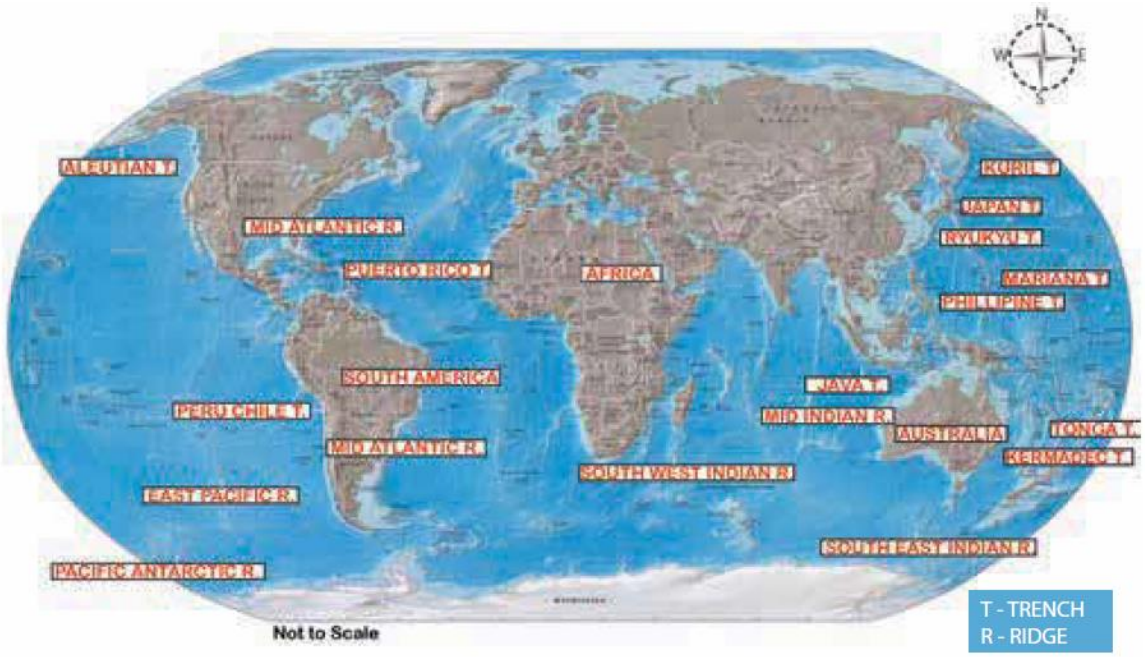
- **Ocean deep** is grouped into **two categories** based on their size.
- Very deep but less extensive depression are called **deeps**.
- Long narrow linear and more extensive depressions are called **'trenches'.**

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 sea floor 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**.



Ridges and Trenches of the World

[Trenches: Aleutian , Puerto Rico, Peru Chile, Java, Kermadec, Tonga, Mariana, Phillipine, Kuril, Japan, KyuKyu

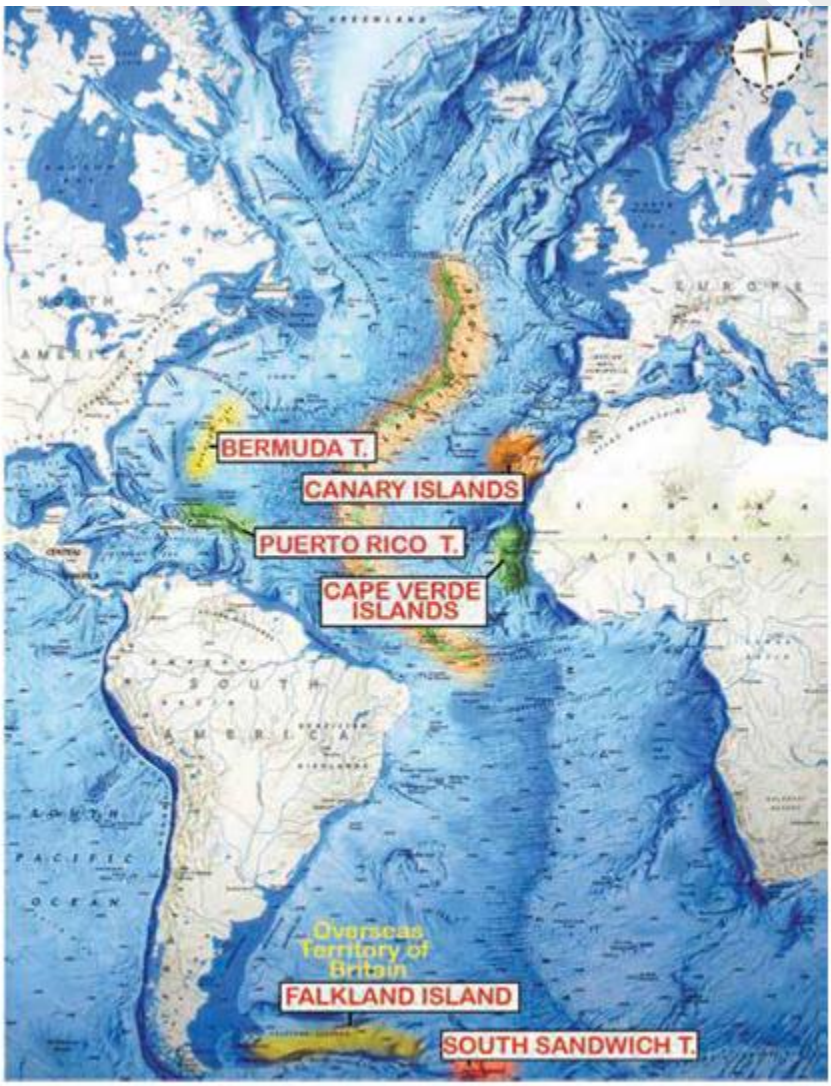
Ridges: Mid Atlantic, East Pacific, Pacific Antarctic, South West Indian, Mid Indian, South East Indian **]**

Bottom relief of Pacific Ocean

- **Continental shelf** of the **Eastern Pacific Ocean** is very narrow due to the presence of trenches while those on the western coast are wide.
- Continental shelf adjoining coasts of **Australia** and **Indonesia** varies in width from **160** to **1,600 km.**
- In the Pacific Ocean, the abyssal plains are very vast.
- Absence of mid oceanic ridges is the main reason for deep sea plains.
- Prominent submarine ridges of the **Pacific Ocean** are **Albatross plateau**, **Cocas ridge** and **Aleutian ridge.**
- **Tasmania basin** (New Zealand) and east pacific basin are major basins of Pacific Ocean.
- Pacific Ocean has about **25,000 islands**. There are number of **archipelagos** both in **North** and **South Pacific Ocean**.
- **The Hawaii islands** were formed by **hotspot**.
- The challenger deep in **Mariana trench** is the deepest part of Pacific Ocean (**10994m**).

Bottom relief of Atlantic Ocean

- In the North Atlantic Ocean, extensive continental shelves are found around the shores of **Newfoundland** (Grand bank) and **British islands** (Dogger Bank).
- In the South Atlantic Ocean, a very extensive continental shelf is found between **Bahia Blanca** and **Antarctica** .
- The most striking relief feature which is the **'S'** shaped **Mid–Atlantic ridge** which extends for 16,000 km from Iceland in the north to **Bouvet Island** in the south.
- The ridge separates the **Eurasian Plate** and **North American Plate** in the **North Atlantic**, and the **African Plate** from the **South American Plate** in the **South Atlantic**.
- **Iceland** and **Faroe** are the few peaks of the Mid-Atlantic ridge.



Bottom relief of Atlantic Ocean

[Bermuda trench, Canary islands, Puerto Rico trench, Cape Verde islands, Falkand islands, South Sandwich trench**]**

- The mid-Atlantic ridge divides the Atlantic Ocean into two major basins, i.e., **East** and **West Atlantic basins**.
- Other basins are Spanish basin, north and south Canary basin, Guinea basin, Brazilian basin and Labrador basin.
- **Puerto Rico** Deep (8,380 m) is the deepest of all deeps in the Atlantic Ocean.
- Other deeps are **Romanche Deep** and **South Sandwich Trench**.
- The West Indies is an **island archipelago** near the main land of North America.
- **British Isles** and **Newfoundland** are famous islands, formed on the continental shelf in the **North Atlantic Ocean**.
- **Sandwich island**, **Georgia Island, Falkland** and **Shetland islands** are islands in the **South Atlantic Ocean**.

Bottom Relief of the Indian Ocean

- The Indian Ocean has continental shelf of varying width.
- Continental shelf along the coast of **Arabian Sea**, the **Bay of Bengal** and **Andaman** varies in width from 192km to 280km.
- A variety of **coral reefs** thrive in the warm tropical water of the Indian Ocean.
- Indian Ocean has a continuous central ridge called the **Arabic Indian ridge**.
- Other important ridges include the **East Indian** ridge, **West Australian** ridge, **South Madagascar** ridge.

[Chagos Laccadive Ridge, Sunda or Java Trench, Diamantina Trench, Reunion Hotspot]

- **Basins of Indian Ocean** include **Comoro** basin, **North Australian** basin, **South Indian** basin and **the Arab** basin.

- The average depth of the Indian Ocean is **3890m.**
- **Sunda deep** near **Java** is the deepest part of this ocean (7450m).
- **Madagascar** and **Sri Lanka** are the most prominent islands present in Indian Ocean.
- **Andaman** and **Nicobar islands** in the Bay of Bengal are the raised part of mountains that are the extension of **Arakan Yoma** which forms a part of Himalayas.
- **Reunion Island** is located on a **Hot spot**.

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.

1. Latitude:

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

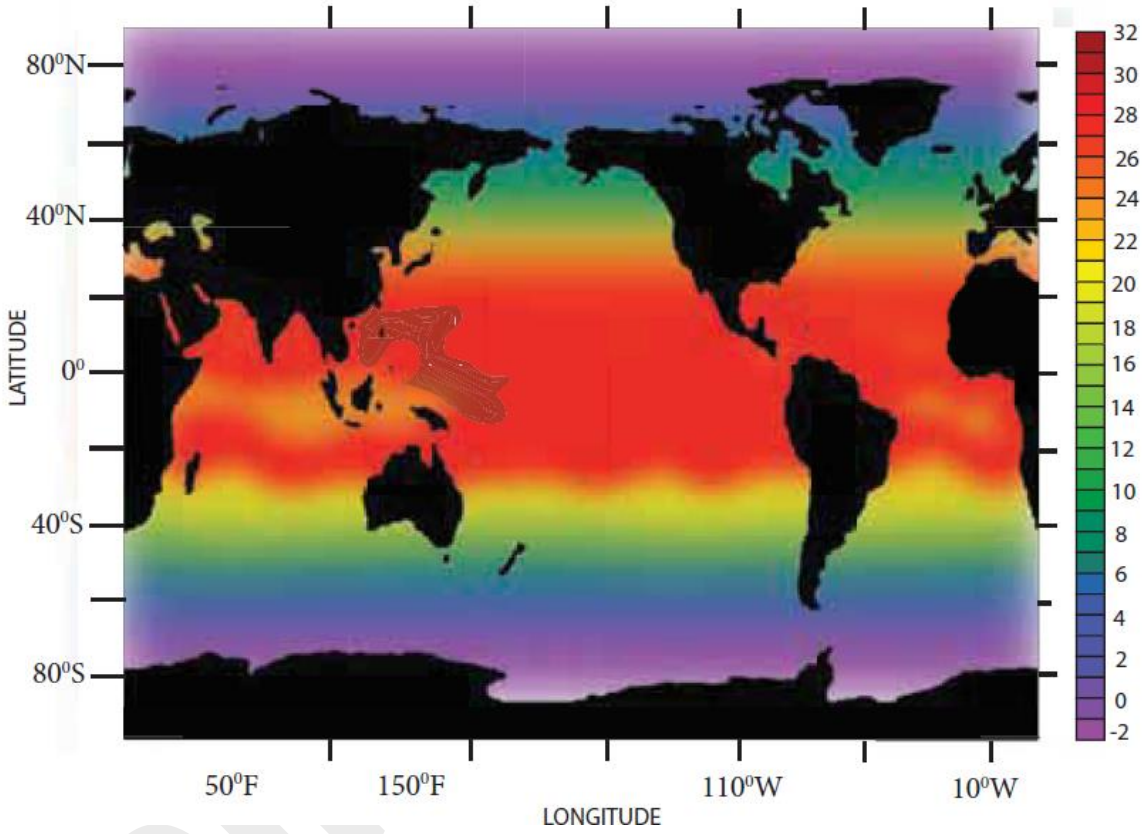
2. Prevailing wind:

- **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.

3. Ocean currents:

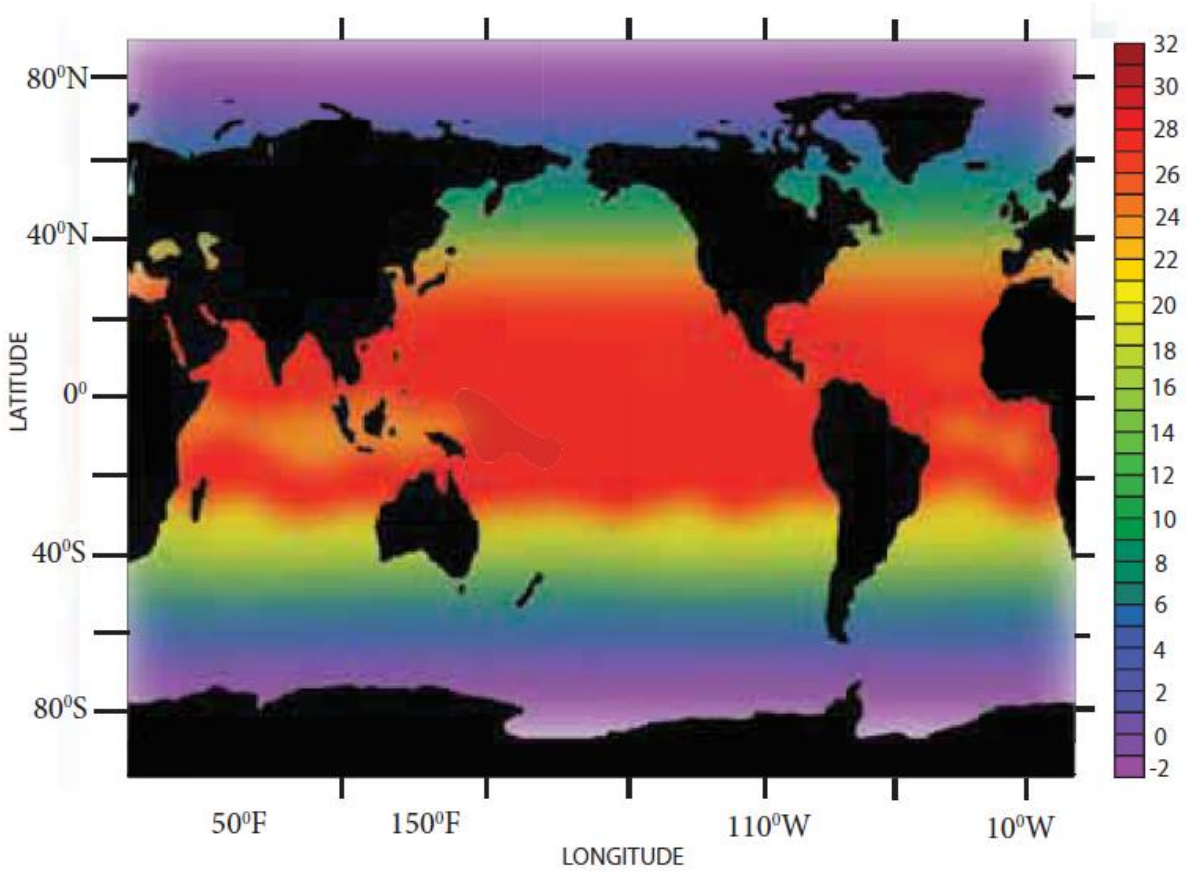
- **Warm currents** raise the temperature of the oceans where they flow whereas cold currents lower down the temperature.
- **Gulf Stream** (warm current) increases the temperature of the eastern part of North America and the west coast of Europe.
- **Labrador cold current** reduces the temperature near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

- These images show the sea surface temperature in **Celsius** shows the sea surface temperature in **July** and in **January**.
- **Cold** temperatures are shown in **purple**, **moderate** temperatures in **aquatic green** and **warm** temperatures in **yellow to red.**
- **Landmass** is shown by **black colour**. The **diurnal range** and **annual range** of temperature of ocean is much less than that of the land.



Sea Surface Temperature in July 1997

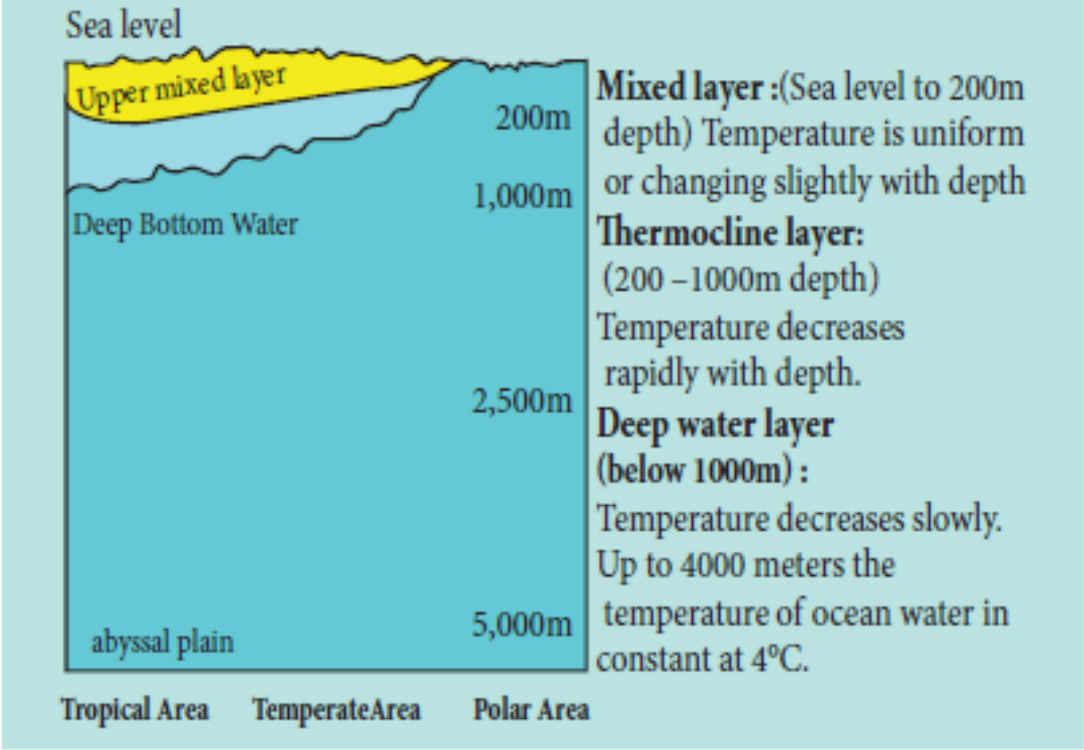
- The temperature of the sea surface is highest (27°C to 30°C) not near Equator but few degrees north of the Equator.
- The **lowest temperature** recorded is **-1.9°C** near the poles.
- The **maximum** and **minimum** annual temperatures of ocean water are recorded in **August** and **February** in the **Northern hemisphere** and reverse in case of the southern hemisphere.

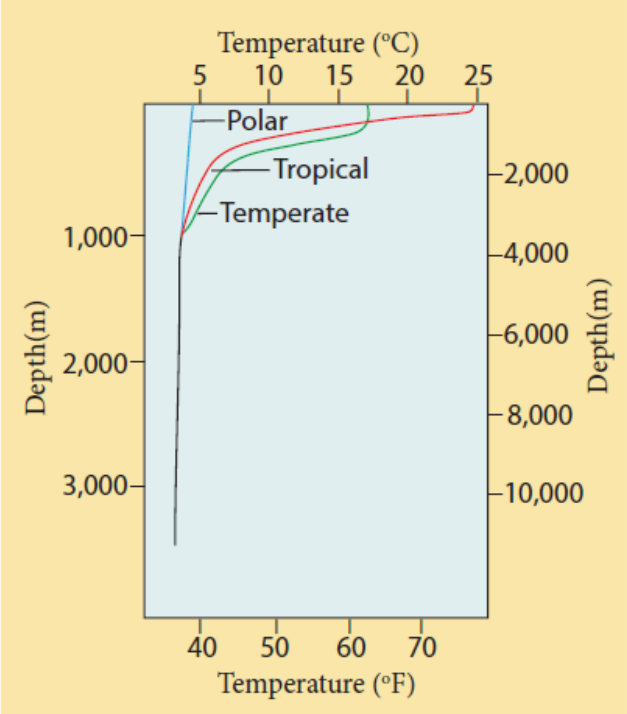


Sea surface Temperature in January 1997

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 metre to 1000 metre**.
- This layer is unique that the temperature decreases rapidly with increasing depth.
- Below the thermocline temperature decrease is gradual up to 4000m.
- Beneath this depth the temperature of ocean water is constant at 4°C.





Vertical Distributions of temperature in Oceans

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.

Fact File

- **Depth of water** is measured in the unit **'Fathom'**. One fathom is equal to **1.8 metre** (six feet)

Factors affecting the salinity of ocean water

- **The salinity** of ocean water depends upon
  a) The rate of **evaporation**
  b) Amount of **precipitation**,
  c) **Addition of fresh water** flow from rivers
  d) **Ice** in Polar Regions
  e) **Upwelling of deep water** initiated by prevailing winds and
  f) **Mixing of water** by ocean currents.

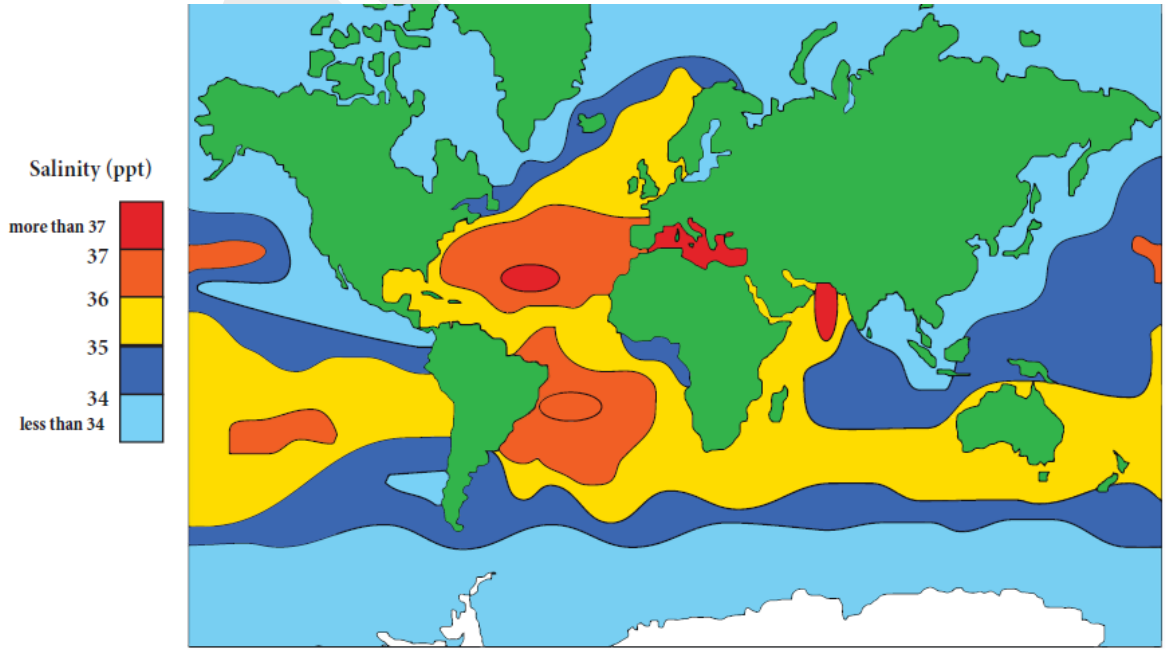
Raking

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 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‰).**
- **Isohaline** is an imaginary line drawn to join places having equal salinity.
- Salinity of **Dead Sea** is 8.6 times saltier than other oceans.

- The shore of Dead Sea is **423m below sea level**.
- It has the lowest elevation on land. The sea is **377m deep.**
- The high salt content will make **people float on the sea.**
- The **high salt content** has made the Dead Sea **devoid of life** in it.



Salinity of the Oceans

Ocean movements

- Water in the **ocean is never** in a **state of rest.**
- Ocean water is **always in motion**. It moves **horizontally** as well as **vertically**.
- The movement of ocean water takes place in three different ways as **waves, tides** and **ocean currents.**

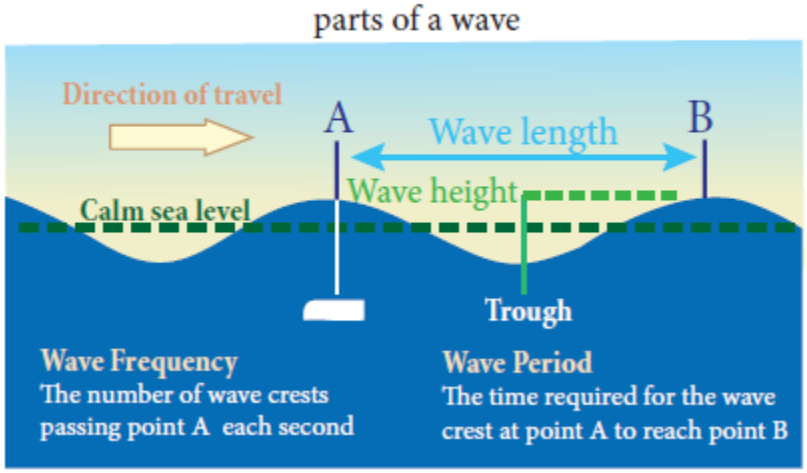
Waves

- The waves are **oscillating movements** in the ocean water which transfer energy from place to place.
- They are caused by **friction of wind** on the surface of water or any other disturbances' on the sea bottom.

Parts of Waves

1. **Crest**: The upper or highest part of a wave is called the crest.
2. **Trough**: The lowest part of a wave is called the trough.
3. **Wave height**: The vertical distance between the crest and the trough is known as wave height.
4. **Wave length**: The horizontal distance between two crests or two troughs is known as wave length.
5. **Wave amplitude**: Wave amplitude is one-half of the wave height.
6. **Fetch**: The distance of open water across which the wind can blow without interruption is called fetch.
7. **Frequency**: The number of wavelengths that pass a fixed point per unit of time is frequency. Example, 100 waves per sec per cm.
8. **Period**: The time taken by one wavelength to pass a fixed point is known as period.
9. **Velocity**: Refers to speed and direction.
10. **Steepness**: Steepness of the wave is equal to the height divided by length.(H/L)

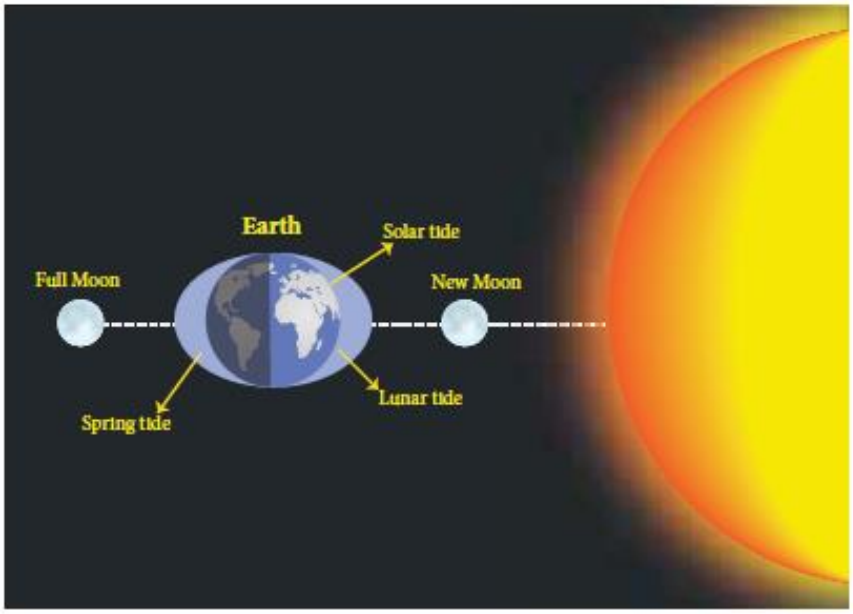
Wave action



Parts of a Wave

Tides

- The **rhythmic rise and fall of the sea water** due to gravitational pull of the moon and the sun is called a **Tide**.
- **Isaac Newton** (1642– 1727) was the first person to explain tides scientifically.
- The rise of seawater towards the land is known as **High tide or flow tide.**
- The fall of seawater more towards sea is known as **'Low tide water'** or **ebb tide.**
- On any day there will be two high tides and two low tides.
- The highest high tide occurs on **full moon day** and **new moon day**. It is known as **spring tide**.
- Spring tide happens when the **sun, earth** and **moon** aligned in **straight line.**
- The lowest low tide is known as **neap tide**. It happens when the sun, earth and moon are positioned at **right angles.**



Tides

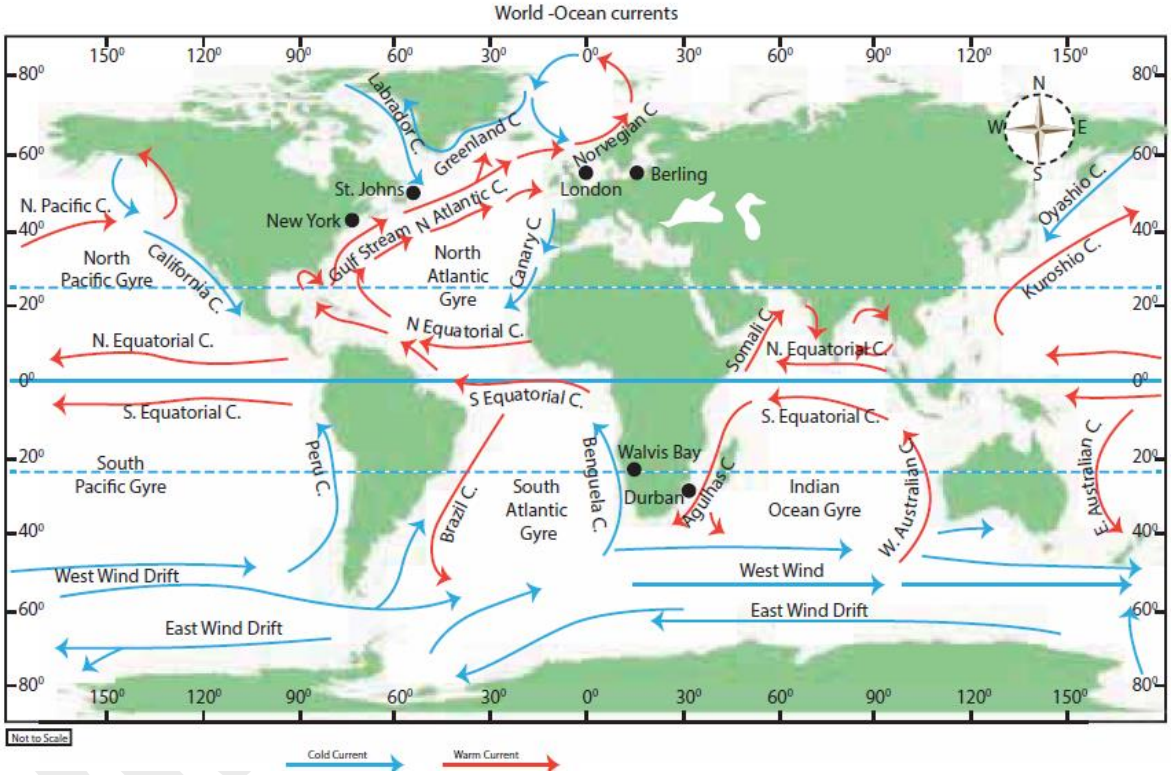
- The movement of ocean water as a result of tidal action is known as a **tidal current**.
- In places of narrow coastal inlet these tidal currents flow rapidly through the mouth with greater height and velocity.
- For example in the Bay of Fundy, between Nova Scotia and New Brunswick of Canada, the difference between high and low tides is as high as 14m.
- Ports which utilize the tidal current for entry and exit of ships from the harbour are known as **tidal ports**.
- In India **Kolkatta** and **Kandla** are examples of **tidal harbours**.
- The **Gulf of Cambay** and the **Gulf of Kutch** in Gujarat on the west coast have the maximum tidal range of 11m and 8m with average tidal range of 6.77m and 5.23m respectively.
- Tides help to clear the sediments deposited by rivers on their bed and thus prevent siltation of harbours.
- **The energy of the tides** is used to **generate electricity**.
- **Tidal power stations** have been set up in UK, Canada, France and Japan.
- In India **Gulf of Khambhat**, **Gulf of Kutch** and **Sundarbans** have scope for **tidal energy production**.

Fact File

- **A harbour** is a **sheltered water body** where ships are anchored.
- **A port** is the area at the **edge of a water body** where boats and ships are docked, where transfer of goods and passengers take place and where trading is facilitated.

Ocean currents

- Large mass of moving water from **one part of the ocean to another** in a definite direction is called as **ocean current**.
- The movement is produced due to **earth's rotation**, temperature difference of ocean water, salinity, density and some extent due to air pressure and winds.
- Ocean currents can be classified on the basis of mode of origin, volume and velocity and boundaries.
- In the order of velocity ocean currents can be classified as **drifts, currents** and **streams**.
- **Drifts** are movement of surface water of **low velocity** influenced by prevailing winds, **currents** are movement of oceanic water in definite direction and **greater velocity** and **streams** are larger mass of water moving in a definite direction and much **greater velocity than the drifts and currents**.



World Ocean Currents

- Ocean currents are distinguished by the temperature they possess.
- When ocean currents originate from equator it is termed as **warm current**.
- Likewise when a current starts from polar region it is termed as **cold current**.
- Vertical circulation of ocean water takes place due to difference in salinity and temperature between the surface and the water deep below.
- **Upwelling** is an oceanographic phenomenon that involves movement of dense, cooler, and usually nutrient-rich water towards the ocean surface, replacing the warmer, usually nutrient-depleted surface water.

- **Down welling** is the process of accumulation and sinking of cold high saline water beneath warmer or fresher water.

Major ocean currents of the world

- In every ocean, there is circulation of ocean water from **Equator to pole** and from **pole to equator.**
- The warm currents from the equator flows over the surface of ocean towards the pole and sink to the bottom of the ocean floor in the higher latitudes due to high density and flow towards the equator to complete the circulation.
- This large scale circulation is known as **gyre**.
- The gyre circulates is **clockwise** in the **northern hemisphere** and **anti-clockwise** in the **southern hemisphere**.

a) Ocean currents of the Pacific Ocean

1. North Equatorial current.

- North equatorial current originates from **Revilla Gigedo island** west of Mexico and flows towards the **Philippines Island** covering a distance of about 12,000 km from **east west**.
- It is a **warm current**.
- It derives from its water from the **Californian current** and the **South east Monsoon** drift which flows north along the **Mexican coast.**
- The volume of water increases from east to west as many small currents join it from right.
- It gets divided into two and the northern branch joins the **Kuroshio Current** and the southern branch abruptly turns and forms the **Pacific counter current**.

2. South equatorial current.

- **South equatorial current** is originated due the action of the trade winds from **east to west.**
- It is a **warm current**.
- It extends for about 13,600km from east to west.
- It is **stronger** than the North equatorial current.
- It is further divided into many **branches** due to the presence of many islands and uneven surface topography.

3. Kuroshio current (Black Tide)

- It is a warm ocean **current flowing in north** easterly direction up to 30o N latitude and it carries warm water off the **Formosa coast.**
- It flows towards north and meets **Oyashio cold current** off the **Kuril Islands**.
- It is also called as **Japan current**.

4. Oyashio Current(Parental Tide)

- It originates from the **Bering Strait** and flows towards south carrying cold water.
- It is a **cold current**.
- It meets with **Kuroshio warm current** and **Aleutian current**.

5. Californian Current.

- **Californian current** is flowing towards south along the **west coast of U.S.A** between 48o N and 23o N latitudes.
- It is **cold current** which exhibits great amount of **up welled water**.
- When it enters the region of Trade winds, it is deflected to the right and joins the equatorial current.

6. Peru Current.

- Peru Current is perhaps the best studied ocean current of the **Pacific Ocean**.
- **Alexander Von Humboldt** in 1802 noted the details of the Peru Current.
- Hence, it is also known as **Humboldt Current**.
- It is a **cold current.**
- It is flowing towards north along the **west coast of South America** carrying cold water from northerly deflection of the **Sub-Antarctica** water moving in 40o S.

7. El Nino or Counter current.

- It is a **warm counter ocean current** of the pacific equatorial waters flowing south ward at 400 m depth to a distance about 180 km.

8. West Wind Drift.

- It is an easterly moving drift in the Pacific Ocean extending from **Tasmania** to the **South American coast**.
- It is a **cold current.**
- The speed of the drift is greater under the influence of **Roaring Forties**.
- It splits into two branches and one moves south around **the Cape Horn** into the Atlantic Ocean and the Other one moves northward along the Peruvian coast due to deflection and joins the **Peru Current**.

b) Currents of the Atlantic Ocean

1. North equatorial current.

- North equatorial current is flowing from **east to west.**
- It is a **warm current**. It is situated between 5o – 20o N latitudes.
- After leaving the west coast of Africa, it attains its main characteristics.

- When it reaches the east coast of South America, it splits into **two branches** and one branch called **Antilles current** is moving along the coast of West Indies and other branch is diverted into the **Caribbean sea.**

2. South Equatorial current.

- It is flowing south of equator within **0degree– 12degree S latitude** in between the coast of Africa and South America.
- It is a **warm current**. It is a northern continuation of **Benguela current**.
- It is **stronger** than the North equatorial ocean current.
- It is caused by the action of **Trade winds.**

3. Gulf Stream.

- Gulf Stream starts from the **Gulf of Mexico** and carries warm waters into the **colder latitudes.**
- It is a **warm current**.
- It bends with the coastline up to **40th parallel** after which the direction is almost to the east, due to the force and the direction of the **westerlies** and the deflective force of the earth.
- It joins the **Labrador cold current** near **New Found land**, **Canada** after passing through the **strait of Florida**.
- **The Gulf Stream** was discovered by **Ponce de Leon** in **1513.**

S. No.	World's Fishing banks	Confluence of ocean currents
1.	The Grand bank (Atlantic Ocean, Western Europe)	Gulf Stream and Labrador current
2.	The Agulhas bank (Atlantic Ocean, South west Africa)	Benguela cold current and Agulhas warm current
3.	The Dogger bank (Atlantic Ocean, North east of N.A)	North Atlantic drift and canary cold current
4.	The Reed bank (South China Sea, Pacific Ocean)	Kuroshio Warm current and Oyashio Cold Current
5.	The Pedro bank (India Ocean)	South Equatorial warm current and W. Australian cold current

4. Canaries Current.

- The ocean current flowing along the Western coast of North Africa between **Maderia** and **Cape verde** is known as the **Canaries Current.**
- It is a **cold current**.
- It is flowing towards south and merging with the **North equatorial current**.

5. Labrador Current.

- In the north Atlantic, a cold current flows from the **Baffin Bay** and **Davis Strait** towards south.
- It brings cold waters from **polar zone** and moves along the **coast of green land**.

6. Benguela current.

- It is a **cold current flowing northward** along the **western coast of Africa** is known as the **Benguela current.**
- It carries cold waters from **sub-Antarctica surface water** and mixes with **south equatorial current.**

The Sargasso Sea – Sea with landless border

- **The Sargasso Sea** occupies about two thirds of the North Atlantic Ocean, stretching seven hundred miles wide and two thousand miles long.
- The only **"sea"** with absolutely no land around it, the Sargasso Sea got its name from common brown seaweed called **Sargassum** that floats in vast mats in its waters.
- The Sargasso Sea is surrounded only by **ocean currents**.

Sargasso Sea

- It lies within the **Northern Atlantic Subtropical Gyre**.
- The Gulf Stream establishes the Sargasso Sea's western boundary, while the Sea is further defined to the north by the North Atlantic Current, to the east by the Canary Current, and to the south by the North Atlantic Equatorial Current.
- Since this area is defined by boundary currents, its **borders** are **dynamic**.

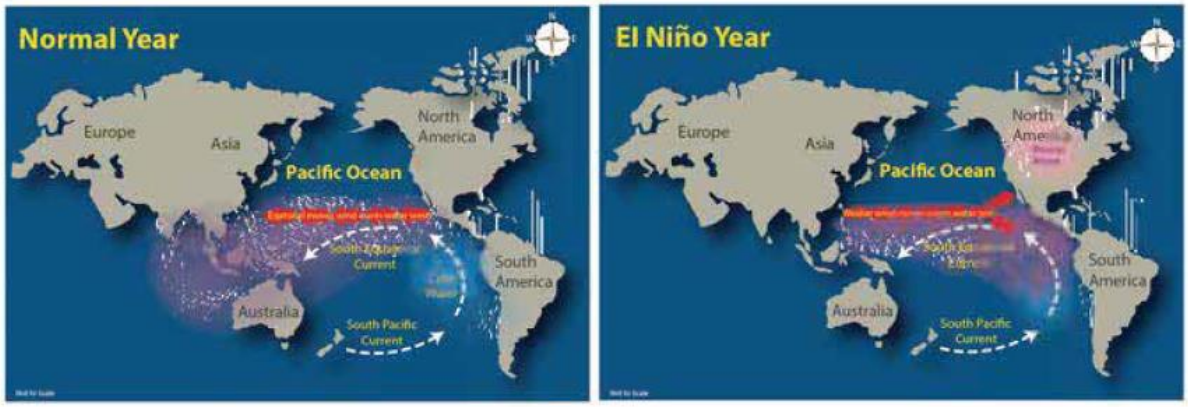
C) Currents of the Indian Ocean

- The **south Indian gyre** is formed by south equatorial current, Madagascar current west wind drift and west Australian current.

- To the north of equator the currents in the Arabian Sea and Bay of Bengal flow in the clockwise direction as southwest monsoon drift and in the anti-clockwise direction as northeast monsoon drift due to the influence of monsoon winds.
- The Antarctic circumpolar current flows between **40 to 60° S latitude**.
- It flows from west to east influenced by the westerly and circles around entire Antarctica.
- There is a **counter west ward current** within this **circum polar current**.

d) Currents of the Southern ocean

- The southern ocean surrounds **the continent of Antarctica**.
- The large oceans, the pacific, the Atlantic and the Indian Ocean merge into this circum global zone of water to their south.
- The movement of water in the southern ocean is in one sense a relatively simple, generally west-east circumpolar drift caused under the influence of north westerly winds.
- This general flow sends offshoots to the three major oceans to its north.
- **The Peru** or **Humboldt Current** in the Pacific Ocean, the **Falkland Current** and the **Benguela Current** in the Atlantic Ocean and the West Australian Current in the Indian Ocean recieve a part of their cold waters from the Southern Ocean.
- Besides the surface currents, there is also a **very complex system** of sub-surface currents between **the southern Ocean** and the **oceans into the north.**
- Generally the water moves from this ocean towards the equator on the surface and at the great depths but at in remediate depth, there is a movement of water from the equatorial areas towards the Southern Ocean.



Wind circulations during Normal and El Nino conditions

The significance of the Ocean Currents

1. **Ocean currents** play an important role in the **earth's climate**. They distribute energy and nutrients within the ocean.
2. **Fog** is formed where **warm current**. For example, when the Gulf Stream and Labrador Current meet near **New Found land one** of the densest fogs is formed.

3. **The warm ocean current** increases the temperature of an area where it flows to and **Cold Ocean current** decreases the temperature of the area.
4. **The warm current** brings **heavy rainfall** when the wind blows over it becomes warm while the cold current brings drought when the wind blows over it becomes cold and dry. For example, the wind blowing over the **Peru Current** is cold and dry causing the formation of the **Atacama Desert** located on the west coast of Peru.
5. It regulates the **global temperature**. It gives free navigation.
6. **The Gulf Stream** keeps ports and harbours of Russia and Scandinavia navigable throughout the year.
7. **The Kuroshio Current** makes port on Japan navigable during the winter.
8. It distributes minerals and pollution added to it becomes highly diluted and later negligible.
9. It helps in the growth of juveniles of certain fish and its distributions to other countries-from its place of origin.
10. Some up welling and down welling are due to currents which bring minerals to **photic zone** used by **phytoplankton**.
11. Major fishing grounds are located in the zones where cold current and warm current meet.

El Nino

- El Nino is a phenomenon that occurs in the equatorial Pacific Ocean characterized by a positive sea surface temperature departure from normal (1971-2000 base period) in the region lying within the latitude 5°N to 5°S and longitudes 120° W to 170°W . This phenomenon occurs every two to seven years.

El Nino happens when

- Sea surface temperature increases between the central and eastern equatorial Pacific Ocean between the country **Ecuador** and the **International Date Line** The increase in temperature is sustained for a period of eighteen months to Two years.
- The temperature increase is up to **30 m beneath the ocean surface**.
- When there is a modified vertical air circulation **above the Pacific Ocean**

Global influence of El Nino

- **El Nino effect** is experienced at **Global level.**
- The change in air circulation affects the economy of different countries also.
- Global weather patterns are altered to such an extent that they affect eco system, agriculture, tropical cyclone, drought, forest fire, floods and flood related health hazards.

Normal Situation	El Nino Situation
➢ Near equator the water of the Pacific Ocean is warmer in the western side and cooler in the eastern side due to upwelling of the cold current. ➢ Air (Walker) circulation is dominant in the western Pacific Ocean. The air ascends in the western side and descends over the cooler eastern side ➢ Heavy rain is experienced in the western warmer region and dry conditions prevail in the cooler region. ➢ The Southeast Asia and Australia receive heavy rain on normal years. ➢ West coast of South America experiences dry weather.	➢ Near equator the warm water in the Pacific Ocean extends from western side to eastern side suppressing the ➢ upwelling of the cold water. ➢ Air (Walker) circulation is dominant in the eastern part of Pacific Ocean. The air ascends in the warm eastern Pacific Ocean. ➢ Heavy rain is experienced in the eastern warmer region and dry condition prevails in the western part. ➢ Southeast Asia and Australia experience dry weather conditions. ➢ West coast of South America receives heavy rainfall.

- El Nino influences the **jet streams.**
- Due to this phenomenon California experiences heavy rainfall, northern Europe experiences dry winter, Southern Europe experiences mild wet winters, there are less number of cyclones in Sea of Japan, and heavy rain in East Africa.
- **South East Asia** experiences severe **drought** and **forest fire**.
- **Peru in South America** receives **heavy rainfall** during **El Nino.**
- Increase of temperature in the east Pacific Ocean is correlated with normal monsoon conditions in India while the **increase of temperature** in the central Pacific has high correlation with **drought conditions in India.**
- When temperature increases further to the west it suppresses the Indian Monsoon.

La Nina

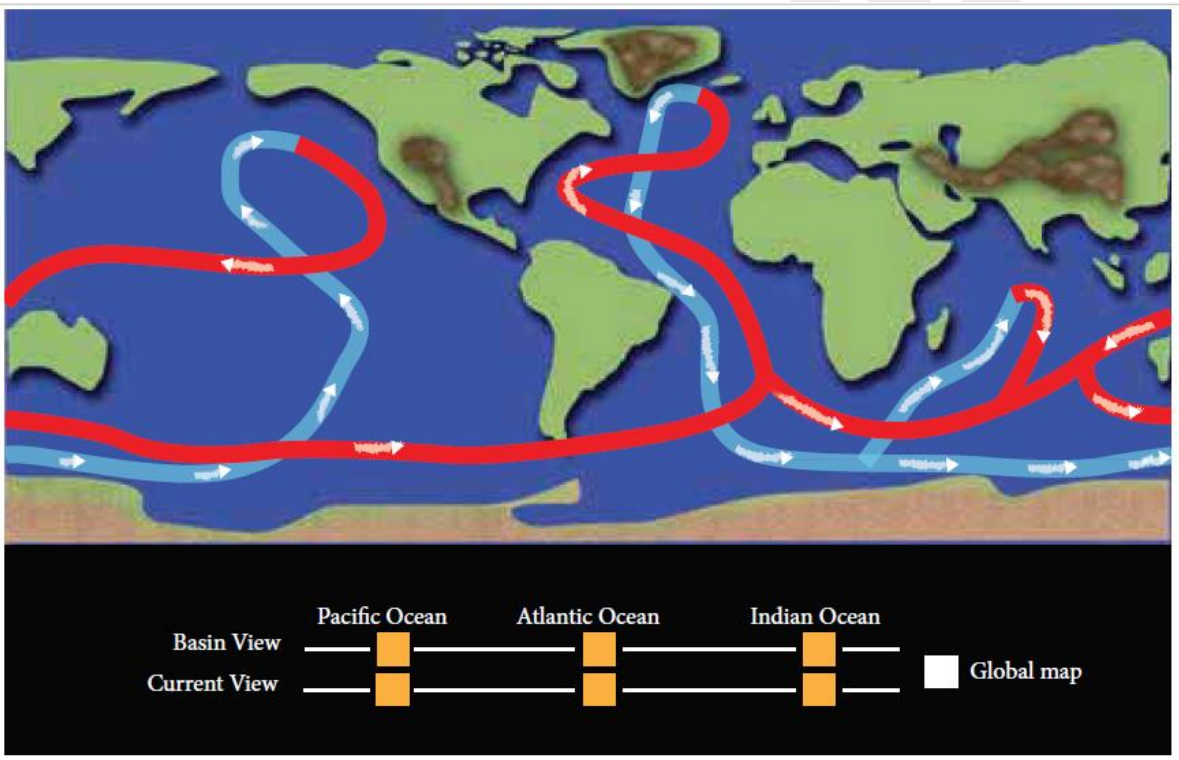
- **La Nina** is just the **opposite** to the condition of **El Nino**.
- When trade winds are strong, **colder water up wells** on the East Pacific Ocean, walker air circulation is confined to the west Pacific, wet condition in Southeast Asia and dry weather in South America is observed.
- The difference in the atmospheric pressure between the west and east tropical Southern Pacific Ocean is referred to as Southern Oscillation.
- **Meteorologists** have established a close inter link between Southern Oscillation and occurrences of El Nino and La Nina events.
- The acronym **'ENSO'** (El Nino Southern Oscillation) is often used to study both the phenomena.

Fact File

- Peruvian fishermen named the weather phenomenon **El Nino** meaning **'little boy'** or **'New born Christ'** and **La Nina** meaning **'Little girl'** as the phenomenon was first noticed during Christmas time.

Thermohaline circulation

- As the name indicates there is a **large scale churning of ocean water** due to difference in temperature and salinity.
- **The down welling of ocean water** occurs in the extreme ends of Atlantic Ocean one near the Norwegian coast and another at **Weddell Sea.**



Thermohaline circulation

- Upwelling of cold water occurs in the North Pacific Ocean and in the Indian Ocean.
- This cycle of water movement within **the Global Ocean** is also known as **Conveyor Belt .**
- The slow, steady and three dimensional flow of water in the conveyor belt distributes dissolved gases and solids, mixes nutrients and carries it to various ocean basins.
- This cycle provides a **stabilizing effect** on **climate of the earth.**
- If it is disturbed, it is capable of causing sudden climatic change within the period of a few decades.
- The conveyor belt is a simplified version of actual circulation in the oceans.

MORE TO KNOW:

- 70% of **human brain** is water.
- **263 rivers** either cross or demarcate international political boundaries.

WRIS

- A nationwide water resources information system, "Generation of Database and Implementation of **Web Enabled Water Resources Information System** (India-**WRIS**) in the country" contain all aspects of water resources and related data provide data and information in public domain through **India-WRIS Web GIS portal.**

Saltwater intrusion

- If excessive **water is taken** from the **aquifers** along the coast, the sea water enters the coastal aquifer.
- This process is termed as **saltwater intrusion.**

Cyrosphere

- **Carbon** is removed from the atmospheric cycle by cryosphere during the formation of ice and is released when the ice melts.

Wilson Cycle

- There is **life cycle** for oceans too! It is known as Wilson cycle.

Ocean and Sea

- In partially enclosed seas, their **bottom relief** and the **submarine ridges** with shallow water do not allow free mixing of open sea water.
- The temperature at the depth of 1800m in **the Red Sea** is **higher** than the **temperature** recorded at the same depth in the Indian Ocean.
- **Raking** refers to the use of a rake, a **traditional wooden tool** with the long handle and long pointed wooden toothed spade at the bottom for **collecting salt**.

El Nino

- **International Research Institute** Climate Prediction Centre predicts and forecasts El Nino occurrences.
- Scientists are in the opinion that **El Nino can cause Global Warming** and it also increases the frequency of El Nino occurrence.