CHAPTER 11

Hydrosphere

Syllabus

Hydrosphere: Meaning of Hydrosphere.

Tides — formation and pattern

Ocean Currents — their circulation pattern and effects. (Specifically of Gulf Stream, North Atlantic Drift, Labrador Current, Kuroshio and Oyashio)

The earth appears blue when viewed from outer space. This is because approximately 71 per cent of the earth is covered in water. ***Hydrosphere*** *refers to the combined mass of water found on the earth such as in oceans, rivers, streams, lakes, in the atmosphere and underground.* The movement of water around, over and through the earth is called water cycle, a key process of the hydrosphere.

The main sources of water on the earth are the following:

(a) Ocean Water: About 97 per cent of the earth's water supply is in the oceans which is unfit for human consumption and other uses due to high salt content. Of the remaining 3 per cent, 2.3 per cent is locked in the polar ice caps. The balance 0.7 per cent is available as fresh water but 0.66 per cent, is ground water and the rest 0.03 per cent is available to us as fresh water in rivers, lakes and streams. Thus, we see that we have a very limited stock of usable water, 0.03 per cent surface water (rivers, streams and ponds) and 0.66 per cent ground water.

(b) Water on Land: Water on land is the result of precipitation or seepage from underground which forms streams and rivers flowing on land and finally joining the sea.

(c) Underground Water: The water from precipitation, that is from rain or snow flows on the surface. Some of the water evaporates and the rest sinks into the soil.

The water which gets collected under the surface of the land is known as underground water which remains in soil, sub-soil or bedrock. Most of the water ultimately reaches the sea. An underground water stream that is saturated with water and transmits water readily is known as an aquifer.

(d) Water in Atmosphere: Water is also present in the form of vapours in the air which gives rise to humidity. Water evaporates from oceans and other water bodies due to heating of surface water. Water vapours condense, form clouds or fog and finally precipitate, causing rain or snowfall.

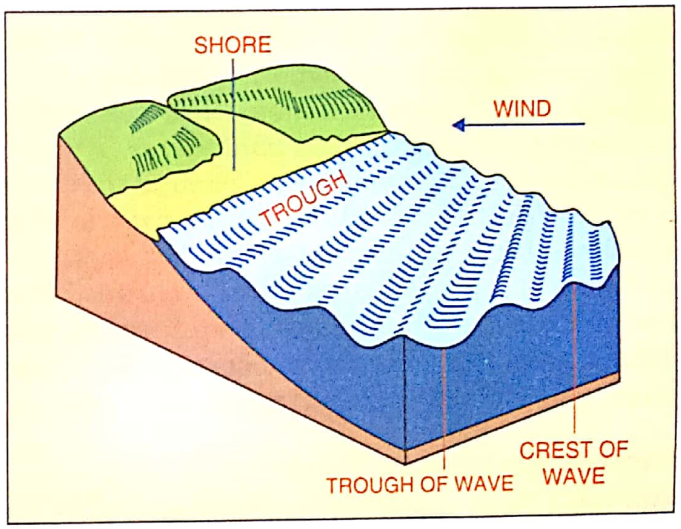

Fig. 11.1. Waves

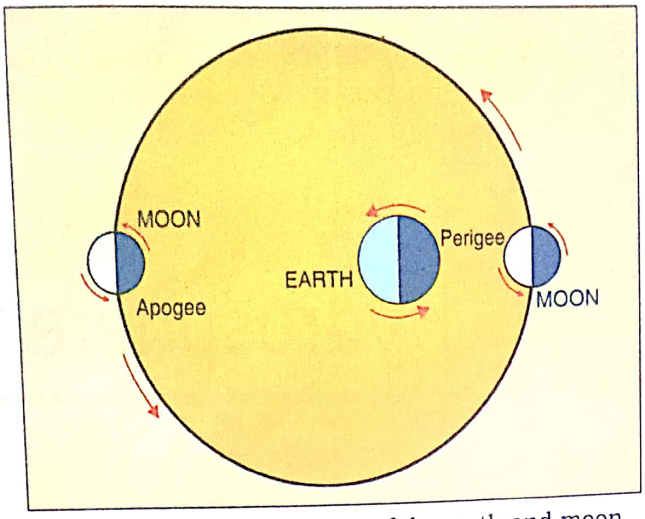

Fig. 11.2. Varying distances of the earth and moon

All the water on earth is connected and is constantly moving. *The circulation of water among atmosphere, hydrosphere and lithosphere is called* ***Hydrological Cycle.*** Water cannot be created, nor it can be destroyed. It can only be transformed into different states.

The movement of ocean waters takes place in three different ways, viz., through waves, currents and tides.

WAVES

Waves *are oscillatory movements in water, manifested by an alternate rise and fall of the sea surface.* These moving ridge-like curves on the surface of the sea are mainly produced by winds on the surface of the oceans.

TIDES

The rise and fall of sea water due to gravitational forces of the sun and the moon are called ***tides.*** Tidal currents affect the whole water mass from the sea surface to the bottom. The sea waves produced by tides are called *tidal waves. The rise of sea water and its movement towards the coast is called* ***tide*** *and the resultant high water level is known as* ***high tide water.*** *The fall of sea water and its movement towards the sea is called* ***ebb*** *and the resultant low water level is called* ***low tide water.*** The difference between high tide water and low tide water is called *tide range.*

Factors that cause Tides

The tides have their origin in the gravitational forces of the sun and the moon. The earth rotates from west to east and revolves round the sun following an elliptical orbit. Similarly, the moon rotates from west to east and revolves round the earth along an elliptical orbit so that the distance between the moon and the earth changes during different times every month. The period of the farthest distance between the moon and the earth is called *apogee* while the period of the nearest distance is called *perigee.*

The surface of the earth facing the moon experiences maximum gravitational force of the moon, while it will be minimum at the opposite side of the earth. Consequently, the water on the earth's surface facing the moon is attracted and pulled up and thus, the high tide occurs. High tide is also formed at the opposite side of the earth simultaneously because of the reactionary (centrifugal) force of the gravitational (centripetal) force of the moon causing outward bulge of the water (Fig. 11.3).

Nature of the Tides

Two tides and ebbs are experienced twice a every place on the earth's water surface in 24 hours.

High Tides: When the sun, the earth and the moon are in the same line (at the time of full moon and new moon) their gravitational forces work together and high tides are formed (Fig. 11.4).

Low Tides: When the sun and the moon are at the position of right angle with reference t

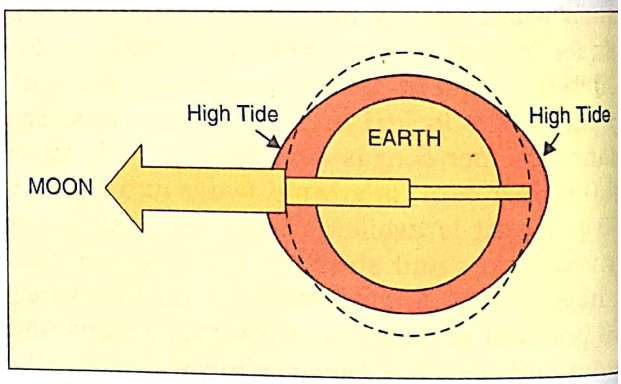

Fig. 11.3. Occurrence of high and low tides due to gravitational forces of the moon on the earth's water surface

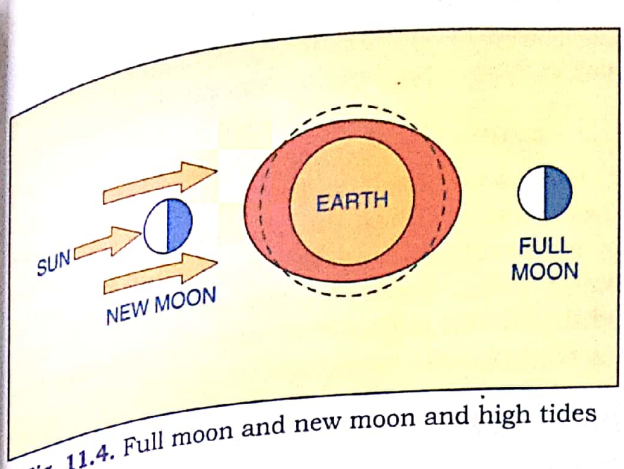

Fig. 11.4. Full moon and new moon and high tides

the earth, the gravitational forces of the sun and the moon work against each other and hence low tides are formed (Fig. 11.5). This situation occurs during the 8th day of each fortnight of a month.

Periodicity of Tides

On an average, every place experiences tides twice a day. Since the earth completes its rotation in roughly 24 hours, every place should experience tide after 12 hours but this never happens. Each day tide is delayed by 26 minutes because the moon also rotates on its axis (west to east) while revolving round the earth. Since the earth rotates from west to east, the tide centre shifts westward. When the tide centre completes one round, the moon's position is ahead of the tide centre by that time. The moon also revolves round the earth, with the result, the tide centre takes another 52 minutes to come under the moon. Thus, a particular tide centre takes 24 hours 52 minutes to come under the moon but by that time there is another tide at the opposite side of the referred tide centre and this happens after 12 hours 26 minutes.

Types of Tides

The oceanic tides are caused due to tide producing forces of the sun and the moon. There is a lot of temporal and spatial variation in the tide producing forces because of different positions of the sun and the moon with the earth. Because of variations in the intensity of tide producing forces several types of tides are caused. Two important types of tides are given below.

(i) ***Spring Tides:*** Very high tide is caused when the sun, the moon and the earth are almost in the same line. Such high tides are called *Spring Tides*. The gravitational forces of the sun and the moon work together with combined force and thus a high tide is caused. The height of such spring tides is 20 per cent more than that of the normal tides. Such tides take place twice every month (during the full moon and the new moon) and their timing is fixed.

(ii) ***Neap Tides:*** The sun, the earth and the moon come in the position of quadrature (i.e., form right angle) on the seventh or eighth day of every fortnight of a month. The tide producing forces of the sun and the moon work in opposite direction, with the result, a low tide occurs. Such a tide, which is lower in height than that of the normal tide, is called *Neap Tide*. The height of neap tides is generally 20 per cent lower than that of the normal tides.

Tidal range is not constant but changes depending on the locations of the Moon and Sun. The most extreme tidal range occurs during spring tides, when the gravitational

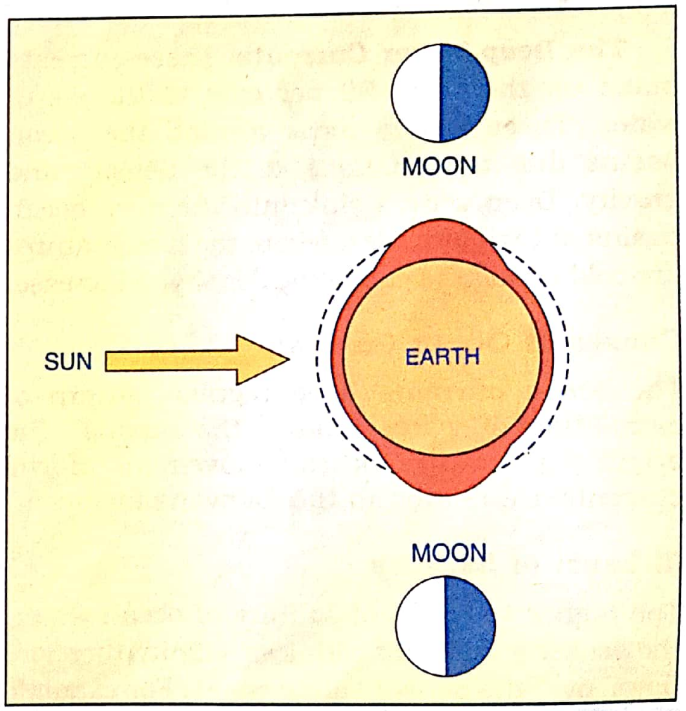

Fig. 11.5. Quadrature and low tide

forces of both the Moon and Sun are alligned, reinforcing each other in the same direction (new moon) or in opposite directions (full moon).

OCEAN CURRENTS

Ocean currents are large masses of surface water that circulate in regular patterns around the oceans, e.g., the North Atlantic Drift, Labrador Current, Benguela Current, etc.

Based on temperature, Ocean currents can broadly be divided into two categories—the warm and the cold currents.

The Warm Currents: These are those currents which flow from the low latitudes in Tropical Zones towards the high latitudes in the Temperate and Sub-polar Zones. They bring warm water into cold water areas.

The Cold Currents: These currents have a lower surface temperature and bring cold water into warm water areas. These currents flow in the high latitudes from the Polar regions towards the low latitudes in the warm Equator region.

Based on their depth the ocean currents can also be divided into two categories:

The Surface Currents: These currents constitute about 10 per cent of all the water in the ocean, and lie at the upper 400 m of the ocean.

The Deep Water Currents: These currents make up the other 90 per cent of the ocean water. These waters move around the ocean basins due to variations in the density and gravity. Deep waters sink into the deep ocean basins at high latitudes, where the temperatures are cold enough to cause the density to increase.

Causes of Ocean Currents

The ocean currents have regular pattern of circulation of water around the oceans. The origin and nature of the movement of the currents are related to the following factors:

(i) Level of Salinity

The higher the level of salinity of ocean water, the denser it is. Water with less salinity therefore flows, over the denser saline water. For example the Mediterranean Sea is more saline as compared to the Atlantic Ocean; so the Atlantic water flows into Mediterranean Sea's surface.

(ii) Temperature

The oceans near the Tropics and Equator are much warmer than the ocean water in the polar or temperate regions. Therefore warm Equatorial water move towards poles as warm currents, while cold ocean currents move towards Equator as cold ocean currents.

(iii) The Earth's Rotation

Since the speed of rotation of the earth is maximum at the Equator, all moving bodies (winds and ocean currents) move in a clockwise direction in the Northern Hemisphere and anticlockwise direction in the Southern Hemisphere, e.g., Canary current and Gulf stream in Northern hemisphere and Peruvian and West Wind Drift in Southern hemisphere.

(iv) The Planetary Winds

The planetary winds play a dominant role on the flow of ocean currents.

(a) *Trade Winds*: Trade Winds blow between the Equator and the Tropics. These winds move Equatorial waters polewards and westwards. They warm the eastern coasts of continents. For example:

(i) The North-East Trade Winds move the North Equatorial Current to warm the eastern coasts of Japan as the Kuroshio Current.

(ii) The South-East Trade Winds drive the South Equatorial Current which warms the eastern coast of Australia as the warm East Australian Current.

(b) *Westerlies*: Westerlies blow in the temperate latitudes and result in a North-easterly flow of water in the Northern Hemisphere and the opposite in the Southern Hemisphere. For example:

(i) The Westerlies force the warm Gulf Stream to the western coast of Europe as the North Atlantic Drift.

(ii) They cause the cold West Wind Drift to flow towards the Equator and the Peru Current along South America and the Benguela Current along South Africa.

(c) Monsoon Winds: The strongest influence of prevailing winds on flow of current is seen in the North Indian Ocean. Due to the monsoon winds the direction of the currents change from south-west in summer to the north-east in winter.

(v) Land
A land mass obstructs the flow of water of an ocean current and diverts its movement. For example, at Cape Sao Roque, the South Equatorial Current gets divided into two branches, one joins North Equatorial Current and the other becomes the Brazil Current.

CIRCULATION PATTERN OF OCEAN CURRENTS

Ocean currents are greatly influenced by the stresses exerted by the prevailing winds and Coriolis force. The oceanic circulation pattern roughly corresponds to the Earth's atmospheric circulation pattern. The air circulation over the oceans in the middle latitudes is mainly *anticyclonic* (more pronounced in the southern hemisphere than in the northern hemisphere). The oceanic circulation pattern also corresponds with the circulation of air. At higher latitudes, where the wind flow is mostly cyclonic, the oceanic circulation follows this pattern. In regions of pronounced monsoonal flow, the current movements are influenced by the monsoon winds. Due to the Coriolis force, the warm currents flow from low latitudes to move to the right in the northern hemisphere and to their left in the southern hemisphere. The cold waters of the Arctic and Antarctic circles move towards warmer water in tropical and equatorial regions, while the warm waters of the lower latitudes move polewards.

1. The Gulf Stream, together with its northern extension towards Europe, the *North Atlantic Drift*, is a powerful, warm, and swift Atlantic Ocean current that originates in the Gulf of Mexico, exits through the Strait of Florida, and follows the eastern coastlines of the United States and Newfoundland before crossing the Atlantic Ocean. At about 30°W, 40°N, it splits in two, with the northern stream crossing to northern Europe and the southern stream recirculating off West Africa.

The Gulf Stream influences the climate of the east coast of North America from Florida to Newfoundland, and the west coast of Europe. In fact, the climate of Western Europe and Northern Europe is warmer than it would otherwise be due to the North Atlantic drift, one of the branches from the tail of the Gulf

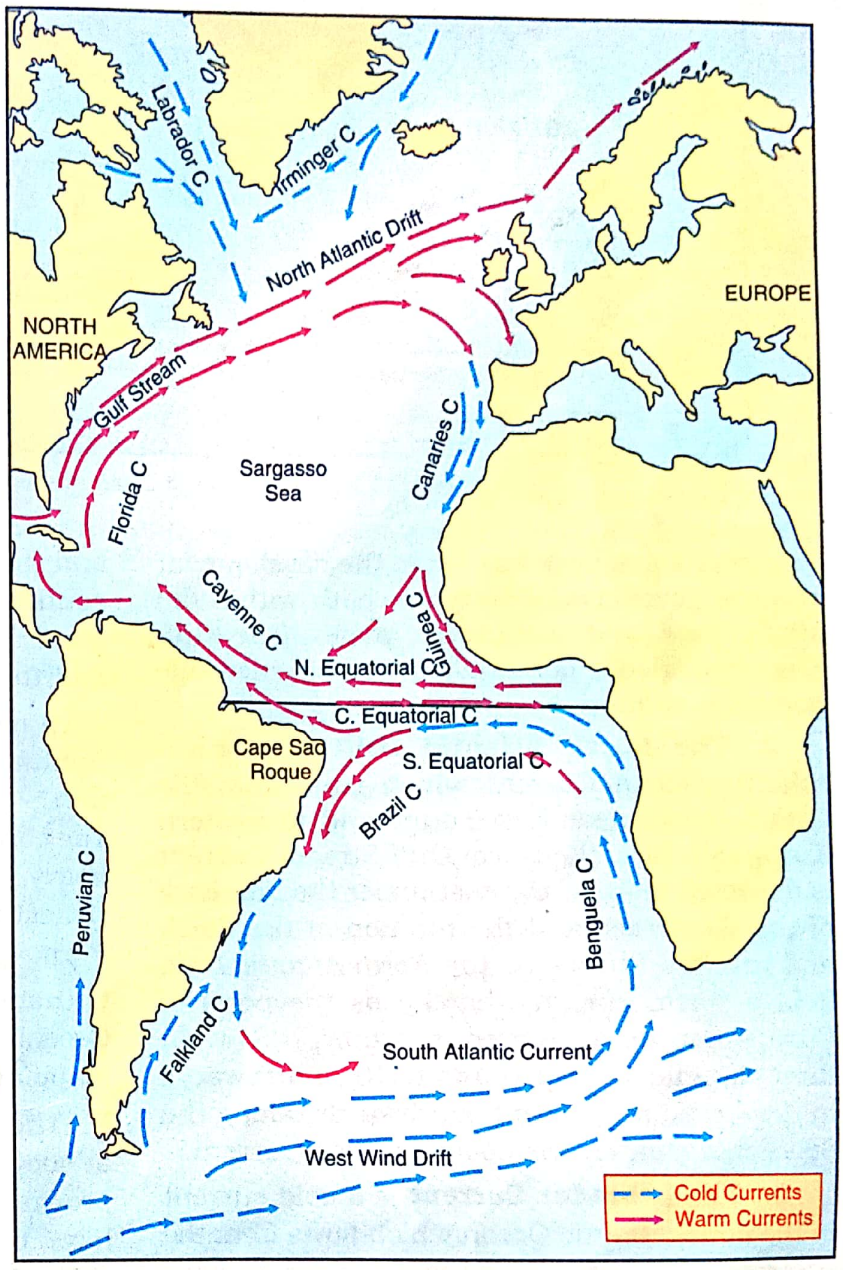

Fig. 11.6. Circulation of Currents in the Atlantic Ocean

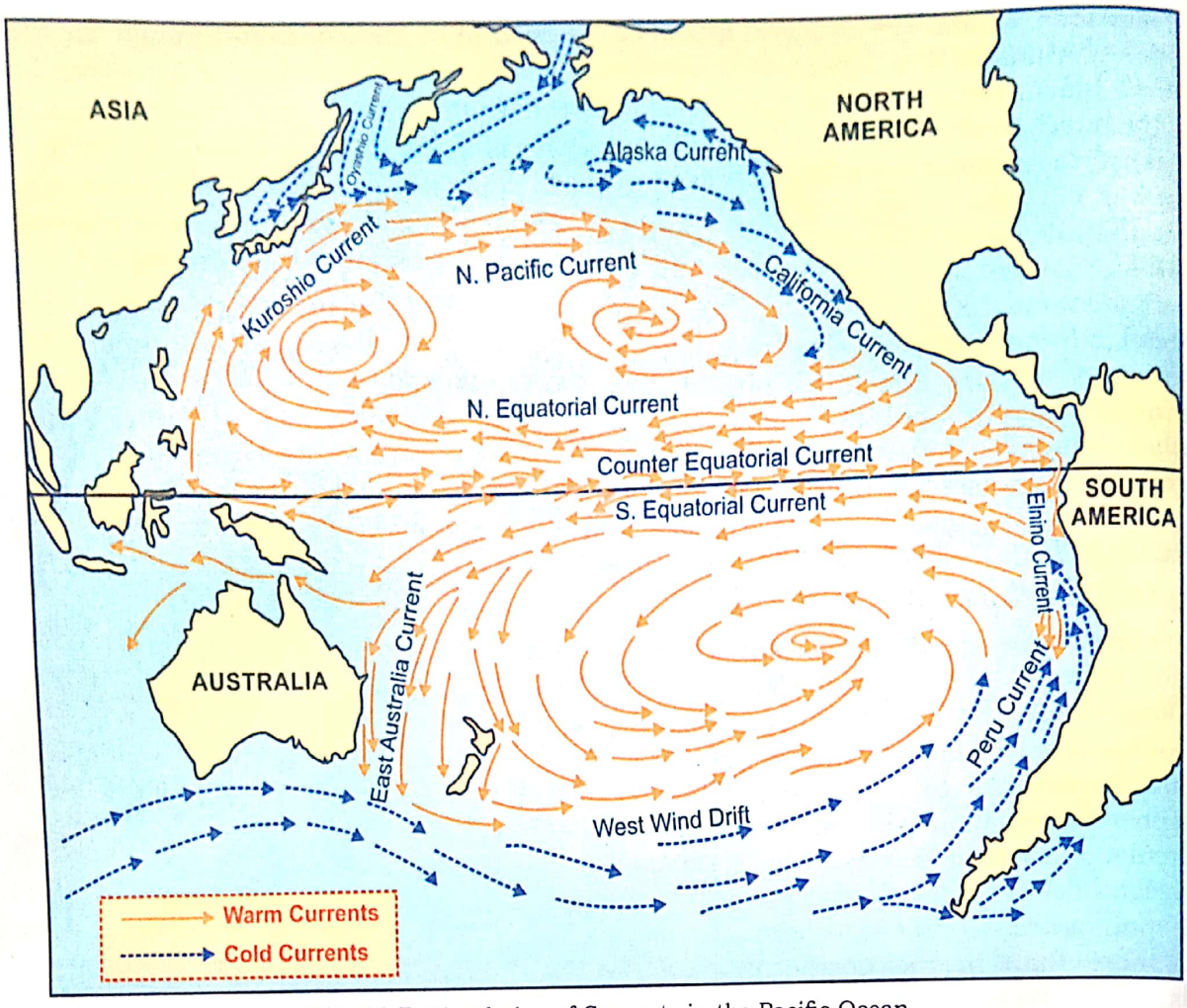

Fig. 11.7. Circulation of Currents in the Pacific Ocean

Stream. Its presence has led to the development of strong cyclones of all types, both within the atmosphere and within the ocean. The Gulf Stream is also a potential source of renewable power generation.

2. The North Atlantic Drift is a warm Atlantic Ocean Current which runs from the Grand Bank, near New Foundland to western Europe. In fact, the warm Gulf Stream Current is deflected towards the east under the influence of the Westerlies and the rotation of the Earth and reaches Europe as the *North Atlantic Drift*. It is a warm current that keeps the ports of Europe free from ice even in winter. It flows in three directions—eastwards to UK, northwards to the Arctic region and southwards, along the Spanish coast, as the cool Canaries Current.

3. The Labrador Current is a cold current in the north Atlantic Ocean which flows from the Arctic Ocean south along the coast of Labrador and passes around Newfoundland, continuin south along the east coast of Nova Scotia. It i a continuation of the West Greenland Curren and the Baffin Island Current.

It meets the warm Gulf Stream at the Gran Banks south-east of Newfoundland and agai north of the Outer Banks of North Carolina The combination of these two currents produce heavy fogs and has also created one of th richest fishing grounds in the world.

In spring and early summer, this curren transports icebergs from the glaciers Greenland southwards into the trans-Atlanti shipping lanes.

The waters of the Labrador Current hav a cooling effect on the Canadian Atlanti provinces and coastal New England, but rare have a significant effect on waters south Cape Cod.

4. The Kuroshio Current is a strong western boundary current in the western north Pacific Ocean. It begins off the east coast of Taiwan and flows north-eastward past Japan, where it merges with the easterly drift of the North Pacific Current. It is analogous to the Gulf Stream in the Atlantic Ocean, transporting warm, tropical water northward towards the polar region. It is also sometimes known as the *Black Stream*—the English translation of Kuroshio, and an allusion to the deep blue of its water—and also as the *Japan Current*.

Its counterparts are the North Pacific Current to the north, the California Current to the east, and the North Equatorial Current to the south.

The warm waters of the Kuroshio Current sustain the coral reefs of Japan, the northernmost coral reefs in the world. The branch into the Sea of Japan is called *Tsushima Current*. It brings rich fisheries from the East China Sea into the Sea of Japan.

There is a concentration of uranium passing through this current every year (between 5 and 6 million tons).

The Japan Current is also responsible for the mild weather experienced around Alaska's southern coast.

5. The Oyashio Current is a cold Subarctic ocean current that flows south and circulates counter-clockwise in the western North Pacific Ocean. It collides with the Kuroshio Current off the eastern shore of Japan to form the North Pacific Current.

The waters of the Oyashio Current originate in the Arctic Ocean and flow southward via the Bering Sea. The current has an important impact on the climate of the Russian Far East, mainly in Kamchatka and Chukotka.

The waters of the Oyashio Current form probably the richest fishing grounds in the world owing to the extremely high nutrient content of the cold water and the very high tides (up to ten metres) in some areas, which further enhances the availability of nutrients. It also causes Vladivostok to be the most equatorward port to seasonally freeze and require ice-breaking ships to remain open in winter. However, this has relatively little effect on the fish yield through the Sea of Okhotsk because the large tides mean freezing does not occur so easily.

THE EFFECT OF OCEAN CURRENTS

1. Effect on Climate

The climate of the coasts becomes warm or cool according to the current washing the coast which may be warm or cool.

(i) *Temperature*: Warm or cold ocean currents flowing near a coast exert a significant climatic influence. The warm Equatorial currents tend to raise the temperature of the places where they flow. The Labrador Current remains frozen for nine months on account of the influence of the cold Arctic Current, while the British Isles enjoy a mild climate on account of the influence of the warm North Atlantic Drift. The otherwise hot climate of Peru is greatly cooled by the Peru Current. On account of the influence of the North Atlantic Drift the harbours of Norway, even beyond the North Cape are free from ice throughout the year, while Greenland in the same latitudes is ice-bound all the year round. The warm Kuroshio keeps the ports of the Alaskan coast ice-free in winters.

(ii) *Rainfall*: The air above the warm ocean current becomes warm and acquires greater capacity to absorb moisture. Thus, the winds help in increasing the amount of precipitation in the affected coastal areas. For example, the North Atlantic Drift, the Kuroshio Current bring in sufficient rainfall along the western coasts of Europe and eastern coasts of Japan respectively.

On the other hand, cold currents discourage rainfall. For example, Kalahari desert along the western coast of South Africa and Atacama desert along the western coast of South America owe their existence to some extent to Benguela and Peru Currents respectively.

(iii) *Fog*: Dense fog occurs where the warm and cold ocean currents meet. The air above warm current is warm and acquires a lot of water vapour. When it meets the cold air above cold ocean currents, the water vapours of the warm air are condensed into minute water particles which form fog. Japanese coast has dense fog when the warm Kuroshio Current

meets the cold Oyashio Current. Similarly, New Foundland where the warm Gulf Stream meets the cold Labrador current creates a dense fog.

(iv) *Violent Storms*: Violent storms follow the line of meeting of cold and warm currents. The hurricanes which occur off the coast of United States follow the line where Gulf Stream mingles with the cold Labrador Current.

2. Effect on Marine Organisms

The sea has innumerable microscopic organisms which are called planktons. The fish feed on planktons. Ocean currents move organic material off the coast which is the food of planktons. The more the planktons, higher the concentration of fish.

3. Effect on Commerce

(i) On account of the influence of warm currents, harbours are kept open in winter, facilitating trade throughout the year. For example, the coasts of UK, Norway, etc., should normally freeze in winter but due to warm ocean currents, they remain unfrozen and trade remains unfettered. In fact the warm Gulf Stream affects even such a place as Spitsbergen which is situated deep in the north. Montreal at the mouth of the St. Lawrence River remains open for the whole of the year but Vladivostok is snow bound for almost the whole of the year due to cold curren along the coast.

Fig. 11.8. Marine Organisms

(ii) Sailing vessels are aided or hindered b the direction of currents. Such vessel from England, bound for Australia mov towards Rio de Janeiro in order to hav a favourable current across the Sout Atlantic and the southern ocean.

(iii) Danger to ships is caused by the Iceberg that flow in cold currents. Due to fog the ships are not able to locate them Many ships have sunk on account o accidents with these icebergs. Howeve in modern times radar helps the ship to locate icebergs even in the darknes of dense fogs.

Terms to Remember

Hydrosphere : The combined mass of water found on the earth surface such as oceans, rivers, streams, lakes, in the atmosphere and underground.

Apogee : The point in the orbit of the moon or a satellite at which it is farthest from the earth.

Perigee : The point in the orbit of the moon or a satellite at which it is nearest to the earth.

EXERCISES

I. Choose the correct option:

1. Hydrosphere refers to the combined mass of water
   (a) in the oceans
   (b) rivers, streams and lakes
   (c) in the atmosphere
   (d) All of the above.

2. Ocean : 97% :: Fresh water : _____
   (a) 3%
   (b) 2.3%
   (c) 0.7%
   (d) 0.66%

3. Underground water is found in:
(a) soil (b) subsoil
(c) underground streams (d) All of the above.

4. Name the oscillatory movements in water, manifested by an alternate rise and fall of the sea surface.
(a) Tides (b) Waves (c) Spheres (d) Oscillations

5. Apogee : Earth-moon distance _____ :: Perigee : Earth-moon distance _____
(a) maximum, minimum (b) minimum, maximum
(c) equal, equal (d) All of the above.

6. _____ flow from the lower latitudes towards the higher latitudes.
(a) Warm currents (b) Cold currents (c) Surface currents (d) Deep water currents

7. Which amongst the following is NOT one of the causes of Ocean Currents?
(a) Level of Salinity (b) Temperature
(c) The Earth's Revolution (d) Planetary Winds

8. Name the winds that blow between the Equator and the Tropics.
(a) Westerlies (b) Trade Winds (c) Monsoon Winds (d) Summer Winds

9. What is the direction of air circulation over the oceans in the middle latitudes?
(a) Cyclonic (b) Hemispherical (c) Spherical (d) Anticyclonic

10. Name the warm Atlantic Ocean Current which keeps the ports of Great Britain ice free even in winters.
(a) The West Atlantic Drift (b) The East Atlantic Drift
(c) The North Atlantic Drift (d) The South Atlantic Drift

11. Which current is also known as the 'Black Stream'?
(a) Atlantic current (b) Kuroshio current
(c) Oyashio current (d) Newfoundland current

12. Name the current that keeps the hub of world trade, the Port of Montreal, open all year round.
(a) Gulf Stream (b) Labrador current
(c) Canaries current (d) Florida current

13. Which currents have created one of the world's richest fishing grounds?
(a) Labrador current and Gulf stream
(b) Labrador current and Irminger current
(c) Oyashio current and Kuroshio current
(d) Both (a) and (c).

14. Currents influence which of the following?
(a) temperature (b) rainfall (c) fish population (d) all of the above.

II. Short Answer Questions

1. Name any two ways in which movement of ocean water takes place.
2. What are tides? Name one factor that causes tides.
3. What is the time interval between tides? Name the factors responsible for this time interval.
4. What are Spring and Neap tides?
5. Name two types of ocean currents based on their temperature. Give an example of each.
6. For what is the Gulf Stream famous?

7. What happens when warm and cold currents meet?
8. Mona had gone to visit her friend's boat on the Visakhapatnam jetty. She was surprised to see that the boats seemed to have sunk because the water level in the jetty was low and the gangways to the boats were almost vertical. As a student of geography name and explain the phenomena that caused this.

III. Structured Questions

1. (a) How are tides formed?
   (b) Differentiate between High Tides and Low Tides.
   (c) Give a reason for each of the following:
      (i) There are two high and two low tides in a day.
      (ii) Each day a tide is delayed by 26 minutes.
      (iii) The tidal range differs from one waterbody to the other.
   (d) Draw a well labelled diagram showing the formation of spring and neap tides.
2. (a) Describing the two types of ocean currents based on their temperature.
   (b) State any two factors responsible for causing the currents.
   (c) Give a reason for each of the following:
      (i) Warm currents produce a milder climate.
      (ii) The eastern coasts of USA are comparatively cold.
      (iii) The coasts of Norway are not frozen in winter whereas its adjoining coasts are frozen for most parts of the year.
   (d) Describe one effect of each of the following three ocean currents.
      (i) Labrador Current of the Atlantic Ocean.
      (ii) The Kuroshio current
      (iii) Oyashio Current of the Pacific Ocean.
3. (a) State the origin and flow of the Gulf Stream.
   (b) What is the effect of Gulf Stream on the coasts of North America and Western Europe?
   (c) Give a reason for each of the following:
      (i) The waters of the Oyashio Current form the richest fishing grounds in the world.
      (ii) There is heavy rainfall in Queensland but the Atacama desert is arid.
      (iii) Rich fishing grounds are located on the Pacific coast of North America.
   (d) Describe three major effects of currents.

IV. Thinking Skills

1. You are watching the sea waves from the balcony of a seaside resort in Mumbai on a New Moon Day. Suddenly you noticed rise of sea water and its movement towards the coast. What was this wave and after how much time will it be repeated?
2. Imagine that the Ocean Currents stop flowing. What would be its consequences for the human beings?

V. Practical/Map Work

1. On an outline map of the world name and show the direction of one warm and one cold current each of the Pacific Ocean and the Atlantic Ocean.
2. Give a diagrammatic representation of the process of the rise and fall of tides.

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