1. Details of Module and its structure

Module Detail	
Subject Name	Geography
Course Name	Geography 01 (Class XI, Semester - 1)
Module Name/Title	Temperature And Salinity of Ocean Water – Part 2
Module Id	kegy_11302
Pre-requisites	Geography has been a part of the teaching of Environmental Studies at the different level of studies. What students have gained in the primary level is the basis for further learning at upper-primary level, where they are introduced to Geography as a separate subject. In previous classes students have learned about ocean and their characteristics. They will broaden their learning about oceans characteristics such as salinity and temperature of oceans.
Objectives	After reading this lesson, learners will be able to: **Temperature** 1. Understand temperature of the ocean. 2. Know sources of heat in the ocean 3. Understand heat budget and distribution of temperature of the ocean **Salinity** 1. Understand salinity of the ocean. 2. Know composition of the salt in the ocean 3. Understand distribution of Salinity of the ocean
Keywords	Temperature, Horizontal and Vertical Distribution, Heat Budget, Salinity.

2. Development Team

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The study of the temperature of the ocean is important for determining the movement and characteristics of large volumes of water, the type and distribution of marine organism at various depths of ocean, the climate of coastal lands etc. Spatial and vertical variations of temperature in found in the various oceans. Ocean waters get heated up by the solar energy just as land. The process of heating and cooling of the oceanic water is slower than land. Ocean water, with an average salinity of 35 per thousand, freezes at -1.94 degrees Celsius (28.5 degrees Fahrenheit). That means at high latitudes sea ice can form. The average temperature of the ocean surface waters is about 17 degrees Celsius (62.6 degrees Fahrenheit). Two of the most important characteristics of seawater are temperature and salinity –together they control its density, which is the major factor governing the vertical movement of ocean waters.

Three types of instruments are used for recording ocean temperatures, viz.

(a) Standard type thermometers are used to measure the surface temperature;

(b) the reversing thermometer are used to measures sub-surface temperature, and

(c) the thermographs.

Nowadays, the automatic self recording instruments are also used instead of the above mentioned thermometers.

Sources of Heat in Ocean

The sun is the principal source of energy for oceans, as for anything else on this earth. Apart from that, the oceans are also heated by the inner heat of the ocean itself. The ocean water is heated by three processes:

1. Absorption of radiation
2. The Convectional current
3. Kinetic energy

Do You Know

The ocean water is cooled by the processes of ***back radiation, exchange of heat*** **and** ***evaporation***.

Factors Affecting Temperature Distribution

The factors which affect the distribution of temperature of ocean water are:

(i) ***Latitude***

The temperature of surface water decreases from the equator towards the poles because the amount of insolation decreases poleward.

(ii) ***Unequal distribution of land and water***

The oceans in the northern hemisphere receive more heat due to their contact with larger extent of land than the oceans in the southern hemisphere.

(iii) ***Prevailing wind***

The winds blowing from the land towards the oceans drive warm surface water away from the coast resulting in the upwelling of cold water from below. It results into the longitudinal variation in the temperature. Contrary to this, the onshore winds pile up warm water near the coast and this raises the temperature.

(iv) ***Ocean currents***

Warm ocean currents raise the temperature in cold areas while the cold currents decrease the temperature in warm ocean areas. Gulf stream (warm current) raises the temperature near the eastern coast of North America and the West Coast of Europe while the Labrador current (cold current) lowers the temperature near the north-east coast of North America.

All these factors influence the temperature of the ocean currents locally. The enclosed seas in the low latitudes record relatively higher temperature than the open seas; whereas the enclosed seas in the high latitudes have lower temperature than the open seas.

The temperature of seawater is fixed at the sea surface by heat exchange with the atmosphere. The average incoming energy from the sun at the earth's surface is about four times higher at the equator than at the poles. The average infrared radiation heat loss to space is more constant with latitude. As a result there is a net input of heat to the earth's surface into the tropical regions, and this is where we find the warmest surface seawater. Heat is then transferred from low to high latitudes by winds in the atmosphere and by currents in the ocean. The geothermal heat flux from the interior of the Earth is generally insignificant except in the vicinity of hydrothermal vents at spreading ridges and in relatively stagnant locations like the abyssal northern North Pacific (Joyce, et al. 1986) and the Black Sea (Murray et al., 1991). Water is transparent, so the radiation penetrates some distance below the surface; heat is also carried to deeper levels by mixing. Due to the high specific heat of water, diurnal and seasonal temperature variations are relatively small compared to the variations on land; oceanic temperature variations are on the order of a few degrees, except in very shallow water. Most solar energy is absorbed within a few meters of the ocean surface, directly heating the surface water and providing the energy for photosynthesis by marine plants and algae. Shorter wavelengths penetrate deeper than longer wavelengths. Infrared radiation is the first to be absorbed, followed by red, and so on. Heat conduction by itself is extremely slow, so only a small proportion of heat is transferred downwards by this process. The main mechanism to transfer heat deeper is turbulent mixing by winds and waves, which establishes a **mixed surface layer** that can be as thick as 200-300 meters or even more at mid-latitudes in the open ocean in winter or less than 10 meters in sheltered coastal waters in summer. Between about 200 m and 1000 m depth, the temperature declines rapidly throughout much of the ocean. This region of steep temperature gradient is known as the **permanent thermocline**, beneath which, from about 1000 m to the ocean floor, there is virtually no seasonal variation and the temperatures are around 2 ^{0}C. This narrow range is maintained throughout the deep oceans, both geographically and seasonally, because it is determined by the temperature of the cold, dense water that sinks at the polar-regions and flows towards the Equator. Vertical distribution of temperature in the deep ocean is controlled by density driven water movements.

Horizontal and Vertical Distribution of Temperature

The temperature-depth profile for the ocean water shows how the temperature decreases with the increasing depth. The profile shows a boundary region between the surface waters of the ocean and the deeper layers.

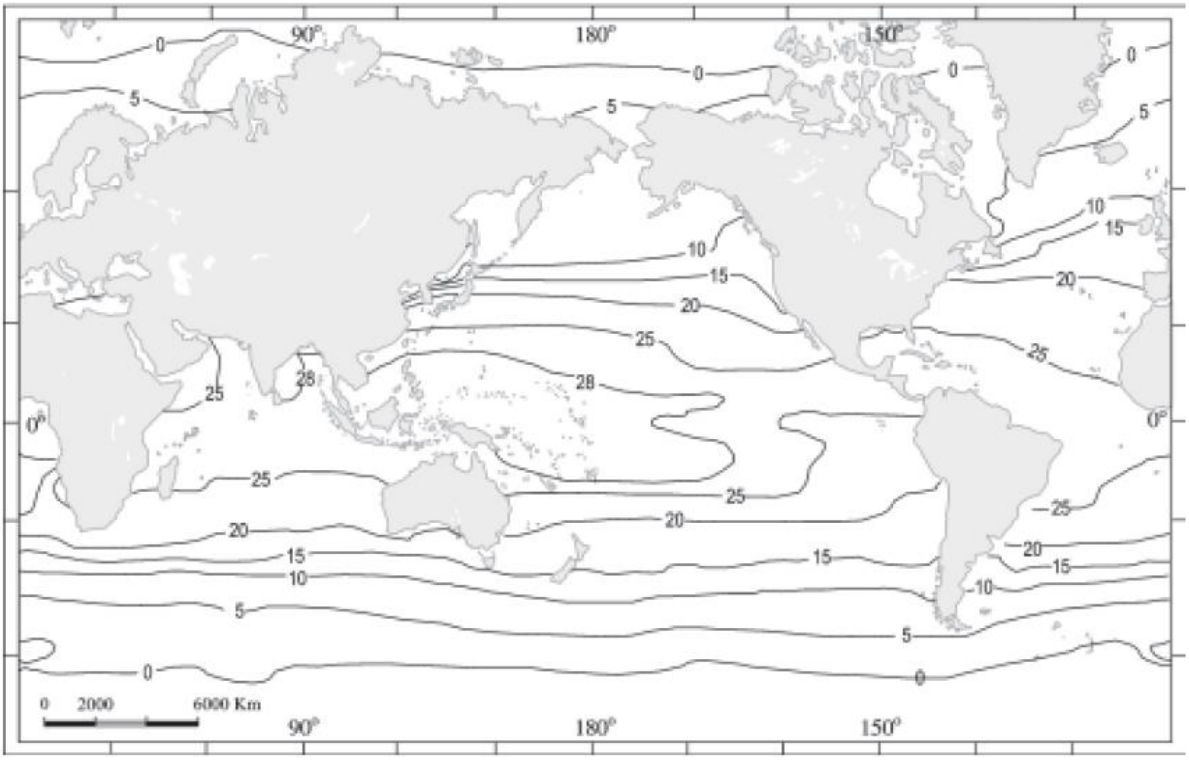

Figure 13.4 : Spatial pattern of surface temperature (°C) of the oceans

The boundary usually begins around 100 - 400 m below the sea surface and extends several hundred of m downward (Figure 13.3 and 13.4). This boundary region, from where there is a rapid decrease of temperature, is called the *thermocline*. About 90 per cent of the total volume of water is found below the thermocline in the deep ocean. In this zone, temperatures approach 0° C. The temperature structure of oceans over middle and low latitudes can be described as a three-layer system from surface to the bottom. The *first layer* represents the top layer of warm oceanic water and it is about 500m thick with temperatures ranging between 20° and 25° C. This layer, within the tropical region, is present throughout the year but in mid latitudes it develops only during summer.

The *second layer* called the thermocline layer lies below the first layer and is characterized by rapid decrease in temperature with increasing depth. The thermocline is 500 -1,000 m thick.

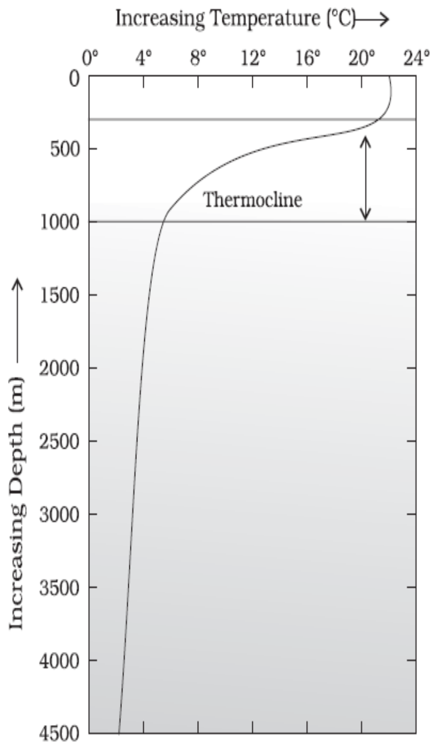

Figure 13.3 : Thermocline

The *third layer* is very cold and extends upto the deep ocean floor. In the Arctic and Antarctic circles, the surface water temperatures are close to 0° C and so the temperature change with the depth is very slight. Here, only one layer of cold water exists, which extends from surface to deep ocean floor.

The average temperature of surface water of the oceans is about 27°C and it gradually decreases from the equator towards the poles. The rate of decrease of temperature with increasing latitude is generally 0.5°C per latitude. The average temperature is around 22°C at

20° latitudes, 14° C at 40° latitudes and 0° C near poles. The oceans in the northern hemisphere record relatively higher temperature than in the southern hemisphere. The highest temperature is not recorded at the equator but slightly towards north of it. The average annual temperature for the northern and southern hemisphere are around 19° C and 16° C respectively. This variation is due to the unequal distribution of land and water in the northern and southern hemispheres. Figure 13.4 shows the spatial pattern of surface temperature of the oceans. It is a well-known fact that the maximum temperature of the oceans is always at their surfaces because they directly receive the heat from the sun and the heat is transmitted to the lower sections of the oceans through the process of conduction. It results into decrease of temperature with the increasing depth, but the rate of decrease is not uniform throughout. The temperature falls very rapidly up to the depth of 200 m and thereafter, the rate of decrease of temperature is slowed down.

Salinity of Ocean Waters

All waters in nature, whether rain water or ocean water, contain dissolved mineral salts. Salinity is the term used to define the total content of dissolved salts in sea water (Table 13.4). It is calculated as the amount of salt (in gm) dissolved in 1,000 gm (1 kg) of seawater. It is usually expressed as parts per thousand ($^{o}/_{oo}$) or ppt. Salinity is an important property of sea water. Salinity of 24.7 $^{o}/_{oo}$ has been considered as the upper limit to demarcate ‘brackish water’.

You may know that the oceans cover about 70 percent of the Earth's surface, and that about 97 percent of all water on and in the Earth is saline—there's a lot of salty water on our planet. By some estimates, if the salt in the ocean could be removed and spread evenly over the Earth's land surface it would form a layer more than 500 feet (166 meters) thick, about the height of a 40-story office building (NOAA). But, where did all this salt come from? If you get into folk stories and mythology you will see that almost every culture has a story explaining how the oceans became salty. The answer is really very simple. Salt in the ocean comes from rocks on land. Here's how it works:

The salinity of surface seawater is controlled primarily by the balance between evaporation and precipitation. As a result the highest salinities are found in the so-called sub-tropical central gyre regions centered at about 20° to 30° North and South, where evaporation is extensive but rainfall is minimal. The highest surface salinities, other than evaporate basins, are found in the Red Sea. Salinity (S) conceptually _ grams of dissolved (<0.5 _m) inorganic ions per kg of seawater. The average salinity of seawater is S = 35 which means that SW is 3.5% salt and 96.5% H_2O by weight.

Composition of Salt

In every cubic kilometer of sea water there are 41 million tons of dissolved salts. Share of different salts are given below in table 13.4. These salts are mainly of terrestrial origin.

Chlorine	18.97
Sodium	10.47
Sulphate	2.65
Magnesium	1.28
Calcium	0.41
Potassium	0.38
Bicarbonate	0.14
Bromine	0.06
Borate	0.02
Strontium	0.01

Table 13.4 : Dissolved Salts in Sea Water

(gm of Salt per kg of Water)

Role of Salinity

Salinity determines compressibility, thermal expansion, temperature, density, absorption of isolation, evaporation and humidity. It also influences the composition and movement of the sea water and the distribution of the fish and other marine resources. Buoyancy is directly affected by the density of water: the more dense water is, the more buoyancy it will have. The greater the salinity of water, the greater its density; salinity, therefore, increases buoyancy.

Highest salinity in water bodies
Lake Van in Turkey (330 o/oo),
Dead Sea (238 o/oo),
Great Salt Lake (220 o/oo)

Factors affecting ocean salinity

The amount of salinity varies from one part of the ocean to another. This variation is influenced by the following factor.

1. The salinity of water in the surface layer of oceans depends mainly on evaporation and precipitation.
2. Surface salinity is greatly influenced in coastal regions by the fresh water flow from rivers, and in Polar Regions by the processes of freezing and thawing of ice.
3. Wind, also influences salinity of an area by transferring water to other areas.
4. The ocean currents contribute to the salinity variations. Salinity, temperature and density of water are interrelated.
5. Hence, any change in the temperature or density influences the salinity of an area.

Horizontal Distribution of Salinity

The salinity for normal open ocean ranges between 33o/oo and 37 $^{o}/_{oo}$ .In the land locked Red Sea, it is as high as $^{o}/_{oo}$, while in the estuaries and the Arctic, the salinity fluctuates from 0 - 35 $^{o}/_{oo}$, seasonally. In hot and dry regions, where evaporation is high, the salinity sometimes reaches to 70 $^{o}/_{oo}$. The salinity variation in the Pacific Ocean is mainly due to its shape and larger areal extent. Salinity decreases from 35 $^{o}/_{oo}$ - 31 $^{o}/_{oo}$ on the western parts of the northern hemisphere because of the influx of melted water from the Arctic region. In the same way, after 15° - 20° south, it decreases to 33 $^{o}/_{oo}$.
The average salinity of the Atlantic Ocean is around 36 $^{o}/_{oo}$. The highest salinity is recorded between 15° and 20° latitudes. Maximum salinity (37 $^{o}/_{oo}$) is observed between 20° N and 30° N and 20° W - 60° W. It gradually decreases towards the north. The North Sea, in spite of its location in higher latitudes, records higher salinity due to more saline water brought by the North Atlantic Drift. Baltic Sea records low salinity due to influx of river waters in large quantity. The Mediterranean Sea records higher salinity due to high evaporation. Salinity is, however, very low in Black Sea due to enormous fresh water influx by rivers. See the atlas to find out the rivers joining Black Sea. The average salinity of the Indian Ocean is 35 $^{o}/_{oo}$. The low salinity trend is observed in the Bay of Bengal due to influx of river water by the river Ganga. On the contrary, the Arabian Sea shows higher salinity due to high evaporation and low influx of fresh water. Figure 13.5 shows the salinity of the World's oceans.

Vertical Distribution of Salinity

Salinity changes with depth, but the way it changes depends upon the location of the sea. Salinity at the surface increases by the loss of water to ice or evaporation, or decreased by the input of fresh waters, such as from the rivers. Salinity at depth is very much fixed, because there is no way that water is ‘lost’, or the salt is ‘added.’ There is a marked difference in the salinity between the surface zones and the deep zones of the oceans. The lower salinity water rests above the higher salinity dense water. Salinity, generally, increases with depth and there is a distinct zone called the *halocline***,** where salinity increases sharply. Other factors being constant, increasing salinity of seawater causes its density to increase. High salinity seawater, generally, sinks below the lower salinity water. This leads to stratification by salinity.

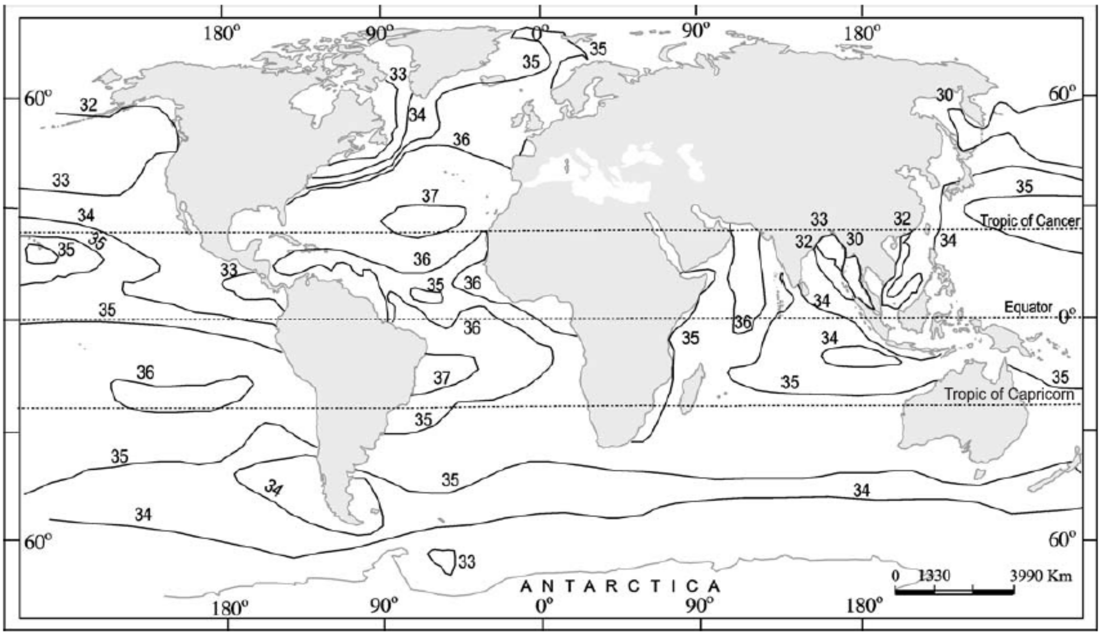

Figure13.5 : Surface salinity of the World's Oceans

High salinity can pose problems for boats. The increased salinity can increase rusting (oxidation) in vulnerable parts, such as motors. This may pose a particular problem in the future, as studies show that tropical waters are becoming markedly saltier. Though scientists are unsure as to the cause of this phenomenon, global warming may play a role. While salinity in tropical and sub-tropical waters has increased, it has decreased in waters farther north. This could have dramatic repercussions for sea life, as well as weather patterns worldwide.