OCEANOGRAPHY
THE ATLANTIC OCEAN
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GEOLOGY
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Objectives

After attending this lesson, the learner should be able to comprehend about the geographic setting of the Atlantic ocean, its dimension, associated water masses, morphological features of the ocean floor, very significant conditions of the ocean, sediments, marine life, marine pollution and other hazards.
In addition, the user should be able to understand, the importance of the Atlantic ocean in the context of global activities including the historical oceanographic explorations.

1.0 Introduction
The world's oceanic water masses occupy about 97 per cent of the hydrosphere. The remaining three percent is frozen in the form of icecaps and distributed in the lakes, rivers, subsurface aquifer, and as water vapour. The world's water is fully loaded in the form of oceanic water masses. These water masses provide a lot of exploitable marine natural resources to the human population. Biodiversity of these marine ecosystems is very unique and exhaustive. Oceans control several global phenomena as well. The seas and oceans cover about 70% of the surface of the Earth, which is equal to 361.1 million sq.km in area. Oceans are fascinating zones of the planet earth. Oceans provide a lot of natural resources and benefits to the life and environment. The Atlantic ocean covers about 20.8% of the total surface of the globe.

1.1 One water body in the Globe:
Oceanic water masses are fully connected and interlinked with each other. If we physically look at these, there is only one water mass existing in the world. The presence of various continents, divide the world's water mass into five major oceans. They are, the Pacific Ocean, the Atlantic Ocean, the Indian Ocean, the Arctic ocean and the Antarctic ocean. Among these, the Atlantic Ocean is the second largest body of water in the world. Each one of these large oceans, include many smaller water bodies as seas, gulfs, or bays and straits. The study of oceanography involves a basic understanding of the geography of all oceans in the world. The oldest known mention of "Atlantic" is in The Histories of Herodotus around 450 BC. The term Ethiopic Ocean, derived from Ethiopia, was applied to the southern Atlantic as late as the mid-19th century.

2.0 Geographic Setting of the Atlantic
The Atlantic is relatively a narrow body of water. It exists between two parallel continental masses.
The Atlantic Ocean touches both the Europe and the Africa on its eastern side. It is bounded by North America and South America along its western region. The Atlantic has no definite northern or southern boundaries. It runs into the Arctic Ocean on the north, and the Antarctic Ocean on the south. Some geographers consider the Arctic Circle as its northern boundary, and the Antarctic Circle as its southern boundary. The ancient Romans named the Atlantic after the Atlas mountains. These mountains rose at the western end of the Mediterranean sea.

2.1 Bordering regions of Atlantic:
The Atlantic is one ocean which is bordered by many countries, their ports and provinces. The Countries and important places surrounding the eastern and western parts of the Atlantic are many**.** Along the west, we could see the following regions:

a) Eastern Provinces of Canada -Newfoundland and Labrador,
b) South Eastern provinces of Canada including Quebec, Florida, Georgia, Columbia, Carolina, Virginia, Washington DC, Maryland, Pennsylvania, New York, Connecticut, Massachusetts, New Hampshire, Mexico, Guatemala, Honduras, Nicaragua, Costa Rica and Panama.
c) The Eastern Atlantic is surrounded by Africa, Europe, Spain, Portugal, United Kingdom, Ireland, and Greenland.

2.2 Areal Extent

The Atlantic covers about 81.5 million square kilometers excluding its gulfs and bays. Including those, its area totals over 106 million square kilometres. The Atlantic covers about one-third of the world's water surface, and over a fifth of the surface of the earth. The parts of the Atlantic ocean are divided as North and South Atlantic oceans above and below the equator. The length of the Atlantic is roughly about 14,000 kilometres. The widest part of the Atlantic lies between Florida and Spain, with a distance of 6,679 kilometres. If the Gulf of Mexico is included as part of the Atlantic ocean then this distance would be 8,000 kilometres. The Atlantic ocean is about 1,500 kilometres wide in the north, between Greenland and Norway. The eastern coastline of the Atlantic Ocean is 51,500 kilometres long, and the western coastline measures upto 88,500 kilometres. The shortest distance across Atlantics ocean is 2575km. It exists between SW Senegal , W. Africa and NE Brazil, E South America.

2.3 Depth

The Atlantic Ocean has an average depth of about 4,000 metres, but the ocean floor is uneven. The floor includes the continental shelf , the deep seated abyss, the mid-oceanic ridges and the deep ocean valleys. The continental shelf lies less than 150 metres below the surface of the water.

The shelf is 480 kilometres wide near North America, southern South America, and most of coasts of Europe. Around Africa and northern South America, the continental shelf is less than 160 kilometres wide. Very steep slopes separate the continental shelf and the abyss of the Atlantic Ocean. Much of the abyss consists of oceanic plains that lie from 4,270 to 5,490 metres deep. The deepest known place in the Atlantic is the Milwaukee Deep which is 8,648 metres below the surface. It forms part of the Puerto Rico Trench, an extremely deep valley in the seabed north of Puerto Rico in the Atlantic ocean.

2.4 Bays and Seas

The Location and size of the Atlantic is very attractive in the world. It's "S" shape is known like a logo. Bays and harbours on the coasts of Europe and North America form an irregular coastline. The coastal borders of Africa and South America are fairly regular in outline. Coastal waters on the eastern side of the Atlantic include the Norwegian, North, Baltic, Mediterranean, and Black seas. The coastal waters on the western side of the Atlantic ocean include the part of the Hudson bay, Gulf of St. Lawrence, the Gulf of Mexico, and the Caribbean Sea. The length of the coastline of the entire Atlantic ocean is 111,866 km.

2.5 Volume of water mass

The total volume of all oceanic waters, in the globe, is about 1370 million cubic kilometers. Out of which, the volume of water existing in the Atlantic Ocean is about 337.210 million cubic.km. Many of the streams empty their freshwater discharges into the Atlantic ocean. It is coming regularly from the world's largest rivers including the Amazon, the Mississippi, St. Lawrence and the Congo.

3.0 Atlantic Ocean Explorations

In 1418, Prince Henry the Navigator founded a school for the study of navigation and sent ships out to explore the world. The period from 1400 to 1700 is considered as the Age of Discovery. Sailors from Portugal first explored the Atlantic coast of Africa in the 1400's. The Portugal's early efforts to explore the Atlantic made people know about the Canary Islands off NW Africa in 1416. Azores (~24^{o}W & 37^{o}N in Atlantic) were discovered between 1427 and 1432. The great age of ocean exploration began in the 15th century. People gained new knowledge from the rediscovery of Ptolemy's (150 A.D.) maps and others expeditions. In the year 1492, Columbus sailed to the Bahamas.

3.1 Discovery of Trade routes

Vasco da Gama reached India in May 1498. His discovery opened up a profitable trade route from Portugal to India. Maps began to improve after 1500, when compasses and better ships did much to encourage the oceanographic explorations. Ferdinand Magellan's expedition between 1519 and 1521, fully circumnavigated the globe. Other important explorers included , Balboa, Ponce de Leon, and Vespucci. Hudson became a heroic figure in nineteenth-century America due to his contributions in oceanographic explorations. The voyages of Bartolomeu Dias, Christopher Columbus, and Vasco da Gama, all astonished the world and tempted many European nations to come out of their medieval isolation. It was then, with the simultaneous discoveries in the East and the West, that exploration and colonization became patriotic duties of their people.

3.2 Beginning of Voyaging for Science

The period from the late 1700's to 20th century, formed the beginning of voyaging for science.
1769 - Benjamin Franklin publishes one of the earliest maps of the Gulf Stream - the strong current system along the U.S. Atlantic coast. It was Matthew Maury(1842), a naval officer of the Depot of charts and Instruments in, who revolutionized the systems of navigation by making clipper ships and the fastest ships of their time. His sounding and bottom-sampling projects were used to make maps of the Atlantic Ocean floor.

3.3 Modern Oceanographic Exploration

The period from 1900 to early 21st century is considered as the Age of Modern Oceanographic Exploration. In the year 1917, Mason of U.S., invented the **ECHO-SOUNDER ,** which was used as a submarine detector. From 1950, as a result of university contributions to the world war effort, government support for academic fraternity, the ocean research and education was greatly increased. This permitted universities to play a major role in ocean studies for the first time. The deep ocean floor exploration and the theory of Plate Tectonics came during the 1960's. Loran navigational system based on radio signals was developed to estimate accurate locations. Current meters were used to measure current velocities and directions. Floats were used to track water movements. Later, the mapping of the slopes of the ocean surface, movement of surface currents, sea surface temperatures, the dynamics of the rapidly changing ocean features , that could not be adequately studied from ships were successfully done using the Earth-orbiting satellites. Today, satellites help in oceanographic exploration, in all oceans.

4.0 Crustal plates and the Atlantic

According to the theory of plate tectonics, the Earth's surface comprises a series of thin plates floating on a semi-liquid mantle. The plates are of two types as oceanic plates and continental plates. Although continental plates are located under the continents, they usually extend into the ocean as well. Oceanic plates are located under the oceans. Every plate has an extensive plate boundary. At plate boundaries, separation allows new crustal material to emerge as in the Mid-

Atlantic Ridges. Where plates move together, typically the edge of one plate will slide under another forming subduction zones.

4.1 Widening Atlantic Ocean

The Atlantic ocean got originated during the Mesozoic era, due to the breaking up of the supercontinent, called Pangea. Due to this continuing plate movements, the Atlantic Ocean is widening at a rate of about 2.5 centimetres per year. As a result of the tectonic movements, cracks are formed, running generally from east to west, in the valley floors of the Atlantic.

5.0 Profile of the ocean floor

The Atlantic Ocean floor is a region of spectacular morphology and contrasting relief features. The most important first oder features is the Mid-Atlantic Ridge. This ridge is extending from the north of Iceland to Bouvet island on the edge of the Southern ocean. The mid-Atlantic ridge was discovered more than 100 years ago. It dives the ocean into two halves, each with a series of major basins delimited by secondary transverse ridges. The ridge extends above the 2000m contour along most of its length. This ridge has a major influence on the circulation patterns of water masses. The Atlantic ocean consists of an extensive continental shelf, continental slope and a set of disseminated deep ocean basins. Beneath the sea, there are broad plains, towering mountain chains, undersea volcanoes, deep trenches and valleys.

5.1 Continental shelf

The continental shelf is the submerged land at the edge of the continents. It begins at the shoreline and gently slopes underwater to an average depth of about 120 to 130 metres. The width of the continental shelf averages 480 kilometres. These are second order physiographic features. Around Africa and northern South America, the width of the continental shelf is less than 160 kilometres. Very steep slopes separate the continental shelf and the abyss of the Atlantic Ocean. The edge of the continental shelf extends to a depth of 20 to 550 m, with an average of 130 m. The continental shelves of the Atlantic ocean consist of huge deposits of sand, mud, and gravels. There is a vast thicknesses of consolidated sedimentary rocks, overlying crystalline rocks. The edge of the shelf is called as the shelf break. It is followed by the Continental slopes.

5.2 Continental Slope

The depth range of the Continental slope of the Atlantic Ocean is around 3,900 meters. The slope is much steeper than the shelf. It plunges to a maximum depth of about 8.6 kilometres. The greatest depth is 8,605 metres.

5.3 Submarine canyons

The Continental slopes are indented by numerous submarine canyons and gullies. A lot of Submarine canyons are found cutting across the shelf and slope. They are often extending from the mouths of the terrestrial rivers. The notable submarine canyons of the Atlantic Ocean are the Wilmington canyon, the Amazon canyon, the Hudson canyon, the Veracruz Canyon, the Congo Canyon, the Carson canyon, Great Bahama Canyon, the Hatteras Canyon, the Alwin canyon, the Oceanographer Canyon, the Lydonia canyon, the Baltimore canyon, the Accomac canyon, the Washington canyon, the Norfolk canyon and the Hedrickson canyon. The Carson canyon has a depth range of 76 to 1129m. The Lydonia Canyon has a depth ranging from 300 to 2100m. The Baltimore Canyon Trough is a great sedimentary basin that exists offshore beyond the shallow depths of the inner New York Bight.

5.4 Deep ocean floor

The deep ocean floor begins at the seaward edge of the continental slope and rise. The average depth is 3660m. Deep-sea peaks, valleys, and plains lie beyond the continental margin. The thickness of sediments, in the oceans, averages about 4000 metres. The deep-sea sediments can reveal much about the earth's history of the last 200 million years. They show the evidences for various processes, including seafloor spreading, the history of ocean life, the behaviour of Earth's magnetic field, the changes in the oceanic currents and paleoclimate. The ocean basins are transient features over geologic time, changing shape and depth while the process of plate tectonics occurs.

5.5 Abyssal plains/hills

Abyssal zone refers to ocean floor depths from 3000 to 6000 m. Bathyal zone refers to ocean floor depths from 200 to 3000 m. Abyssal plains are those parts of the ocean that begin at the edge of the continental margin and continue into the ocean depths. These plains, which are extremely level, are the flattest places on earth and cover approximately one-half of the deep-ocean floor. The flatness of these plains is the result of the accumulation of a blanket of sediments, up to 5 kilometers thick, which overlies the basaltic rocks of the oceanic crust. Abyssal hills are irregular structures on the ocean floor that average about 250 m in height.

5.6 Features of Abyssal plains

Abyssal plains found in the Atlantic and Indian Ocean tend to be more extensive than those in the Pacific Ocean. Abyssal plains are relatively flat areas of the ocean basin with slopes of less than one part in a thousand. They tend to be found at depths of 4,000 to 5,000 m below sea level. Oceanographers believe that the abyssal plains are so flat because they are covered with sediments that have been washed off the surface of the continents for thousands of years. On the abyssal plains, these layers of sediment have now covered up any irregularities that may exist in rock of the ocean floor beneath them. The notable abyssal plains of the Atlantic ocean are the Madeira abyssal plain containing turbidite deposits, the Hatteras and Nares Abyssal plains, the Northeast Atlantic Abyssal plains, the Porcupine Abyssal plain, the Demerara abyssal plains and the Iberian abyssal plains.

6.0 Ocean basins

The deep-sea basins occupy huge spaces in the world's oceans. In the Atlantic Ocean, they are developed on both sides of the Mid-Atlantic Ridge. They produce a kind of symmetry in the general structure of the Atlantic ocean floor. These basins are heterogeneous in terms of their morphology, geology, and deep crustal structure, even though they have some features in common. The notable basins are, the Argentine, the Brazil, the Cape, and the Angola basins in the South Atlantic Ocean and the North American, the Newfoundland, the Canary, the Sierra Leone, and the Iberian basins in the Central Atlantic Ocean. The East Atlantic Basins include, the Iceland Basin, the Cape Verde Basin, the Sierra Leone Basin, the Guinea Basin, the Cape Basin, the Cape Basin, the Angola Basin and the Atlantic Indian Basin. The West Atlantic Basins include, the Labrador Basin, the New foundland Basin, the Sargasso Sea, the Gulf of Mexico, the Caribbean Sea, the Brazil Basin, the Argentine Basin and the Scotia Sea.

6.1 Mid ocean ridges

The most attractive feature of the Atlantic ocean is its great underwater ridge called as the Mid-Atlantic Ridge. As the name implies, this ridge rises in the middle of the ocean. The ridges consist of a chain of mountains that runs about 60,000 kilometres through the three major oceans. Most mountains of the mid-ocean ridges stand about 1,500 metres above the sea floor. It extends between an area near Iceland and an area north of Antarctica. Much of the ridge lies

from 2,100 to 3,000 metres beneath the surface. But it raises above the water in some places and forms the islands like Ascension, the Azores, and Iceland, including Surtsey, a volcanic island that first appeared off Iceland in 1963.
Scientists discovered the mountain chain independently in each ocean and gave it different names, including Mid-Atlantic Ridge, East Pacific Rise, and Mid-Indian Ridge.

6.2 Notable Ridges:
The Mid Atlantic Ridge is a world famous ridge. It is the longest one in the world. It divides the Atlantic in the middle along the plate boundary. Its alignment is broken near the equator. It starts from Iceland in the north and ends near the Rouvet Island near the Antarctica. The Mid Atlantic Ridge is exactly following the boundary of coastlines and continental margins on both sides of the ocean. It is flanked by many ocean basins. The other ridges are, the Reykjanes Ridge, the Madeira Ridge, the Atlantic Indian Ridge, the South Scotia Ridge, the Zapiola Ridge, the Astrid Ridge, the Parnaiba Ridge, the Belem Ridge, the Ceard Ridge, the Barracuda Ridge, the Blake Bahama Ridge, the Eirik Ridge, the West Scotia Ridge, the Newfound land Ridge, the Walvis Ridge, and the Hatton Ridge.

6.3 Rift valleys:
Deep valleys cut across the ridges in many places, producing a rugged, fractured surface. Frequent volcanic activity occurs along such central valleys. Atlantic ocean has some notable valleys. A deep, narrow valley called the Mid-Atlantic Rift Valley, extends along the crest of the Mid-Atlantic Ridge. Earth scientists believe that this valley divides two sets of the great rigid plates that make up the earth's lithosphere, which includes the hard crust and the solid outer layer of the mantle.

6.4 Deep Ocean Trenches
An ocean trench is a long, deep depression in the ocean floor. The oceanic trenches are one of the most striking features of the ocean floors. In the Atlantic Ocean, there are only two trenches. The Puerto Rico Trench is an extremely deep valley in the seabed north of Puerto Rico in the Atlantic ocean. It exists along 20 degrees North. The other one is the South sandwich Trench. The South Sandwich Trench is a deep arcuate trench in the South Atlantic Ocean lying 100 km to the east of the South Sandwich Islands.

6.5 Seamounts
A seamount is an underwater mountain, rising from the ocean seafloor. They are formed by hotspot volcanism. These are also formed from extinct volcanoes that rise abruptly and found rising from the seafloor. They normally rise up to an elevation of 1,000 to 4,000 metres. The smaller submarine volcanoes are called sea knolls. The Atlantic Ocean contains several long seamounts. The South Sandwich Islands constitute a volcanic island arc which results from this active subduction. Mount Belinda on Montagu Island is an active volcano. There are 37 notable seamounts identified so far in the Atlantic Ocean.

6.6 Notable Seamounts of Atlantic:
The St. Helena Seamount chain, is an underwater chain of seamounts in the southern Atlantic Ocean. The chain has been formed by the movement of the African Plate over the Saint Helena hotspot. The New England Seamount chain is an underwater chain of seamounts in the Atlantic Ocean stretching over 1,000 km from the edge of the Georges Bank off the coast of Massachusetts. The chain consists of over twenty extinct volcanic peaks, many rising over 4,000 m from the seabed. The Kiwi Seamount is a seamount in the Atlantic Ocean. It is part of

the New England Seamount chain, which was active more than 100 million years ago. It was formed when the North American Plate moved over the New England hotspot. The Corner Rise Seamounts are a chain of extinct submarine volcanoes in the northern Atlantic Ocean east of the New England Seamount chain. The Seewarte Seamounts, also known as the Atlantis-Great Meteor Seamount Chain and the Atlantis-Plato-Cruiser-Great Meteor Seamount Group, is a north-south trending group of extinct submarine volcanoes in the northern Atlantic Ocean south-southeast of the Corner Rise Seamounts.

6.7 Guyots

The flat-topped seamounts are called as guyots. Many seamounts do not rise to a peak but have a flat top. It is considered that the seamount tops were above sea level at one time and have been removed by wave action. The flattened seamounts later sunk below the ocean surface. Scientists believe the sinking of the guyots was caused by the movement of crustal plates. The Great Meteor Seamount is a large guyot located south of the Azores in the Atlantic Ocean. This guyot rises up from a depth of almost 4,800 meters to about 270 meters below the surface of the Atlantic.

6.8 Icebergs

An iceberg is a large piece of frozen ice that has broken off from a glacier or an ice shelf and is floating freely in open water. Icebergs generally range from 1 to 75 metres above sea level and weigh 100,000 to 200,000 metric tons. From the first voyages across the North Atlantic, icebergs have been a major threat to shipping interests. The most famous disaster was the sinking of the RMS *Titanic* on April 15, 1912. At that time 392 icebergs were recorded. In 1984, 953 icebergs were observed. About 90% of icebergs are found near Newfoundland and the Grand Banks. They come from the glaciers of western Greenland.

7.0 Atlantic Coastal Plains

In the New York City region, the Atlantic Coastal Plain encompasses Long Island, a small portion of Staten Island, and all of southern New Jersey. Long Island and the southern and eastern shores of Staten Island are also part of the coastal plain. The region is underlain by poorly consolidated sedimentary formations of Cretaceous, Tertiary, and Quaternary age that gently dip seaward. The stratigraphy of the Atlantic Coastal Plain records a story of 100 million years of transgressions and regressions of seas across the region. The term "passive margin" is used to describe the current character of the Atlantic side of the continent.

7.1 Islands or island arcs

The Atlantic Ocean contains hundreds of large, medium and small islands. The notable islands in the North Atlantic include, the British Isles, Iceland, Greenland, Newfoundland, the West Indies, Cuba, Dominican Republic, Haiti, Cayman Islands, Jamaica, Virgin Islands, Turks and Caicos Islands, the Azores, , the Canary Islands, and the Cape Verde Islands. The other ones are Jan Mayan Island of Norway, Azores of Portugal, Bermuda of British overseas territory, St Peter & St Paul Rocks of Brazil, Ascension Island of British overseas territory, Bouvet Island of Norway.

8.0 Water masses and Temperature

The temperature of the surface waters in the Atlantic Ocean is governed by the flow of sea-surface currents. Worldwide, the waters around the equator are warmest. The Atlantic Ocean has temperatures that range from below -2 ° C in polar regions to 20 degrees C around equator. It varies with different regions. The temperatures of the Atlantic depend on the latitude, season and

current systems in the region with maximum temperatures being registered in the areas north of the equator while the minimum temperatures are recorded in the polar regions. Temperatures vary by 7 degrees C to 8 degrees C in the middle latitudes.

8.1 Salinity

The surface waters of the North Atlantic have a higher salinity than those of any other ocean, reaching values exceeding 37 parts per thousand in latitudes 20° to 30° N. Three major factors influence salinity (salt concentration) in the Atlantic ocean waters. They are precipitation, evaporation and winds. The salinity of water in the North Atlantic regions are at a higher level than the South Atlantic regions. Near the Equator, precipitation dominates and surface salinities of about 35 parts per thousand are observed. In the Mediterranean Sea, where the runoff is small and evaporation is high, salinity is also high. In the Black Sea and in the Baltic, where large rivers empty their waters, the ocean water salinity is low. Around the Canadian coast, the Atlantic waters are not as salty. The melting of Arctic sea ice, further reduces the salinity of surface waters along Canada's Atlantic coasts.

8.2 Density

The density of pure water is 1000 kg/m3. Ocean water is more dense because of the salt in it. Density of ocean water at the sea surface is about 1027 kg/m3. Less dense water floats on top of more dense water. The term thermohaline circulation refers to a part of the large-scale ocean circulation that is driven by global density gradients created by surface heat and freshwater fluxes. The thermohaline circulation is also called as the ocean conveyor belt. Formation and movement of the deep water masses at the North Atlantic Ocean, creates sinking water masses that fill the basin and flows very slowly into the deep abyssal plains of the Atlantic.

8.3 Thermohaline circulation

In contrast to the wind-driven currents, these are not confined to surface waters but can be regarded as a big overturning of the world ocean, from top to bottom. The thermohaline circulation consists of:
Deep water formation
Spreading of deep waters
Upwelling of deep waters and
Near-surface currents.

9.0 Climate of the Atlantic

The weather conditions over the North Atlantic is largely determined by large-scale wind currents and air masses emanating from North America. Near Iceland, atmospheric pressure tends to be low, and air flows in a counter clockwise direction. Most of the Atlantic Ocean has a mild and moderate climate because ocean water has a balancing effect on temperatures. When cold air mixes with warm water it causes fog, which sometimes poses a big problem for ships. In the Northern Atlantic icebergs break away from ice sheets and drift southwards.

9.1 Effects on Climate:

Blow of Constant winds is seen in all parts of the Atlantic Ocean. Trade winds blow from the Tropic of Cancer and Capricorn to the equator. Between 35° and 60° latitude western winds blow constantly in an eastward direction. They influence the weather in Europe and other continents. Tropical storms form near the equator, causing the creation of hurricanes and cyclones which travel towards the coast and can cause a lot of damage.

10.0 Ocean Currents

Ocean currents result from two processes - the action of wind on the surface of the water, and from variation in water temperature that causes movement- a process known as convection. Convection occurs because the oceanic waters heat up becoming less dense. This water moves above the cooler water, and give off its heat to the surrounding environment. As it cools, it begins to sink, and the process begins again. Convection results in the continual circulation of ocean water on a global scale. There are many factors that determine the strength of a current, as well as the route it will follow. Winds have the most important influence on the flow of currents, but tides, precipitation, evaporation rates, shape of the ocean floor, and inflow from rivers and adjacent seas are also important.

10.1 Notable Currents:

The major currents in the North Atlantic Ocean flow along the eastern North American coast from the Gulf of Mexico to the tip of Labrador. The cold Labrador Current flows from the Arctic, southward along the Labrador Coast. Some of the cold water from this current enters the Gulf of St. Lawrence, but the most of the water continues to move south, dividing into two arms. As the Nova Scotia Current moves southwest over the Scotian Shelf, it mixes with offshore waters as well as water from the Labrador Current and the Cape Breton Current. The Gulf Stream flows north from the Gulf of Mexico, bringing warm, salty water all the way up the east coast to just short of Nova Scotia. This current is of particular importance in warming the Maritime Provinces, as it redistributes the heat from the Caribbean to the cold North Atlantic.

11.0 Marine Life

The first appearance of life on the earth is thought to have occurred in the oceans , in about 2 or 3 billion years ago. Biological oceanography is an important aspect of all oceans. The modern marine environment of oceanic waters, is divided into two major realms as the benthic realm and the pelagic realm.

There is a large diversity of animal and plant life in the Atlantic Ocean. Plankton is the basic plant form in the shelf regions. It provides food for fish and other sea animals. Corals thrive in the Caribbean Sea and other warm areas. More than half of the world's fishing grounds lie in the Atlantic Ocean. For many years overfishing has threatened many fish species in the ocean. Some of them are in danger of becoming extinct. Most of the fish live near the shelf areas of the coast. Many animals migrate from the warmer waters of the Atlantic to colder places. Whales live especially in the northern areas, near Greenland and Iceland.

12.0 Marine sediments

The Atlantic Ocean sediments are composed of terrigenous, pelagic, and authigenic materials. The terrigenous deposits consist of sand, mud, and rock particles formed by erosion, weathering, and volcanic activity on land and then washed to sea. These deposits are largely found on the continental shelves and are thickest off the mouths of large rivers or off desert coasts. Pelagic deposits, which contain the remains of organisms that sink to the ocean floor, include red clays and Globigerina, pteropod, and siliceous oozes. The sediments are covering most of the ocean floor. The thickness of these sediments is ranging from 60 m to 3,300 m. The thickest layers are found in the convergence belts and in the zones of upwelling. The authigenic deposits consist of such materials as manganese nodules. They occur where sedimentation proceeds slowly and wherever the currents played their role to sort the deposits.

13.0 Natural Resources

The Atlantic ocean has also contributed significantly to the development and economy of the countries around it. The natural resources of the Atlantic include, oil and gas fields, fish, marine mammals (seals and whales), sand and gravel aggregates, placer deposits, polymetallic nodules, precious stones.

13.1 Richest Fishing zones

The world's richest fishing resources are found in the waters covering the shelves of the Atlantic.

The major species of fish caught are cod, haddock, hake, herring, and mackerel. The most productive areas include the Grand Banks of Newfoundland, the shelf area off Nova Scotia, Georges Bank off Cape Cod, the Bahama Banks, the waters around Iceland, the Irish Sea, the Dogger Bank of the North Sea, and the Falkland Banks. In addition, Eel, lobster, and whales are also taken in great quantities. The Atlantic ocean continues to provide millions of tons of fish catch every year. Nearly all of the Atlantic fish catch is taken from waters of the continental shelf zone. Important commercial fish species include sea scallops, surf clams, ocean quahogs, and blue mussels. Around the equatorial regions, shrimp, shellfish, and eels are harvested in huge quantities.

13.2 Mineral resources

The Deep Sea Drilling Project, a scientific study of the ocean bottom, took place during the 1960's and 1970's. For this project, oceanographers on the U.S. research ship Glomar Challenger drilled about 100 holes into the Atlantic floor. They obtained fossils and minerals from more than 910 metres beneath the seabed. Exploitable amounts of sand, gravel, and shell deposits occur in the shallow parts of the continental shelf zones. There are also good amounts of offshore placer deposits of precious metals, metallic ores (e.g., of iron, tin, titanium, and chromium), and gemstones are found at various points along the Atlantic coastline. Large amounts of sodium chloride and other salts are being obtained , mostly by solar evaporation, from the waters of the Atlantic and its marginal seas. In addition, commercial operations to extract bromine is done along the northwestern coast of the Mediterranean. Magnesium is extracted along the Gulf Coast of the United States.

13.3 Diamond, Petroleum and Coal

The offshore prospecting for diamond was started in 1961. Valuable diamond deposits were identified in Namibia region. Besides its major "transatlantic" transportation and communication routes, the Atlantic offers abundant petroleum deposits in the sedimentary rocks of the continental shelves. A wealth of petroleum and natural gas lies under the continental shelves and slopes and the oceanic rises and plateaus of the Atlantic basin. Massive coal deposits have also been discovered deep beneath the floor of the North Sea and along portions of the continental shelf regions.

13.4 Deep-Sea Minerals

Ever since the discovery of polymetallic Manganese Nodules in the Atlantic Ocean in 1873, there has been persistent curiosity about seabed minerals. This is an extremely rich deposit of gold and copper in this ocean. In certain regions of the Atlantic ocean floor, red clays and siliceous ooze sediments are found carpeted with polymetallic metallic nodules. These nodules are composed primarily of manganese and iron, with lesser quantities of copper, nickel, and cobalt. The history shows that the ferromanganese nodules were first dredged from the Atlantic ocean way back in the mid-19th century.

14.0 Ports and harbours:

The major parts and harbours of the Atlantic ocean are, Alexandria (Egypt), Algiers (Algeria), Antwerp (Belgium), Barcelona (Spain), Buenos Aires (Argentina), Casablanca (Morocco), Colon (Panama), Copenhagen (Denmark), Dakar (Senegal), Gdansk (Poland), Hamburg (Germany), Helsinki (Finland), Las Palmas (Canary Islands, Spain), Le Havre (France), Lisbon (Portugal), London (UK), Marseille (France), Montevideo (Uruguay), Montreal (Canada), Naples (Italy), New Orleans (US), New York (US), Oran (Algeria), Oslo (Norway), Peiraiefs or Piraeus (Greece), Rio de Janeiro (Brazil), Rotterdam (Netherlands), Saint Petersburg (Russia), and Stockholm (Sweden).

15.0 Hazards

It is a tragic fact the Atlantic ocean has received large amounts of plastic materials during the last few decades. Plastic contamination is cluttering up the ocean and causing problems with sea life and marine birds. Tankers contribute to pollution by cleaning their oil containers on the high seas. Major tanker disasters have repeatedly occurred in the Atlantic. In 2010 the explosion of an oil platform in the Gulf of Mexico caused oil to leak out for over three months. Many pollutants reach the ocean through factories and industries along the major rivers. Densely populated areas along the Rhine in Europe and the Mississippi in North America bring waste and other pollutants into the ocean. Ships often transport heavy metal, chemicals and radioactive waste in barrels and dump them into the sea.

16.0 Conclusion

Understanding of the world's oceans will give very important facts and figures to not only the geologists and geographers but also to all other scientists and engineers, traders and administrators, civilians and defense personnel to know the magnitude of these water bodies and their power in controlling the natural dynamics of the hydrosphere. Understanding of the Atlantic will give a lot of information to know about its oceanography.