Conservation Geography
Dr. Ankur Awadhiya, IFS
Indian Forest Service
Indian Institute of Technology Kanpur
Module - 5
Hydrosphere
Lecture - 13
Structure and composition

Namaste! Today we begin a new module, which is Hydrosphere.

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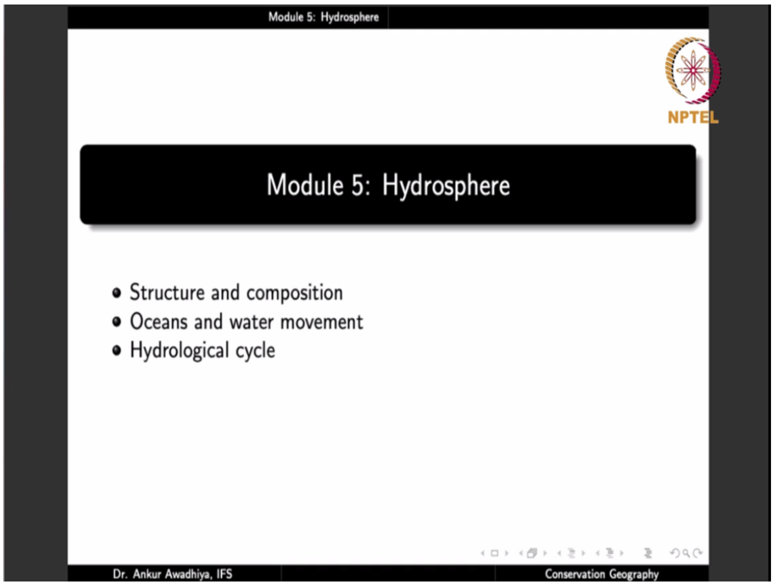

This module will have three lectures Structure and Composition, Oceans and Water movement and Hydrological cycle. So, let us begin with the first lecture.

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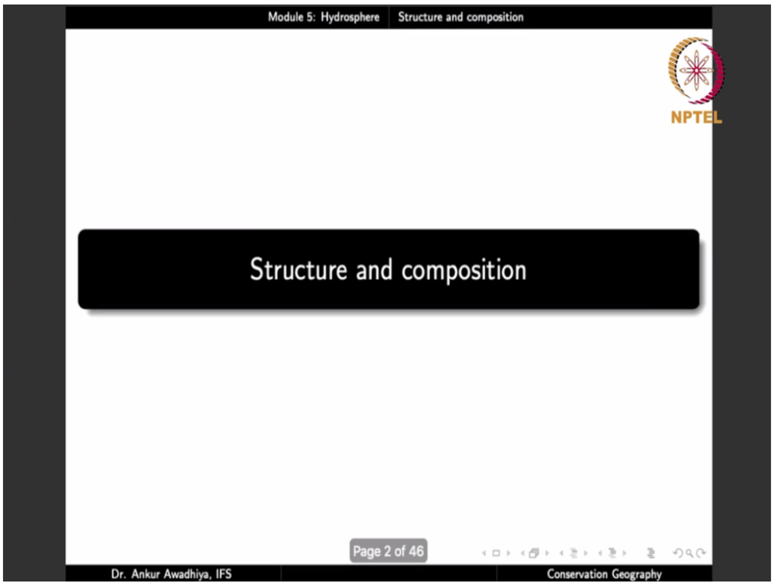

Structure and composition. Now, we have observed before that hydrosphere is one of the four spheres of Earth.

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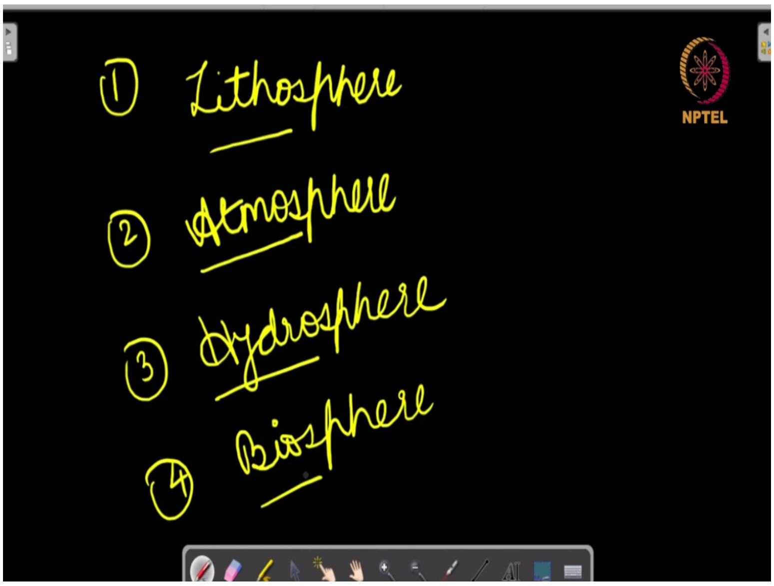

So, we had talked about the first sphere being the Lithosphere, litho means rocks, so, this is the rocky sphere or the solid portion of the Earth. Then we talked about atmosphere where atmos refers to gases, so, this is the gaseous sphere or the envelope of air that surrounds the planet. Now, we are talking about the hydrosphere; hydro means water. So, this is the watery sphere, all the water that is contained in this planet. And the fourth sphere is the biosphere which is the livings sphere.

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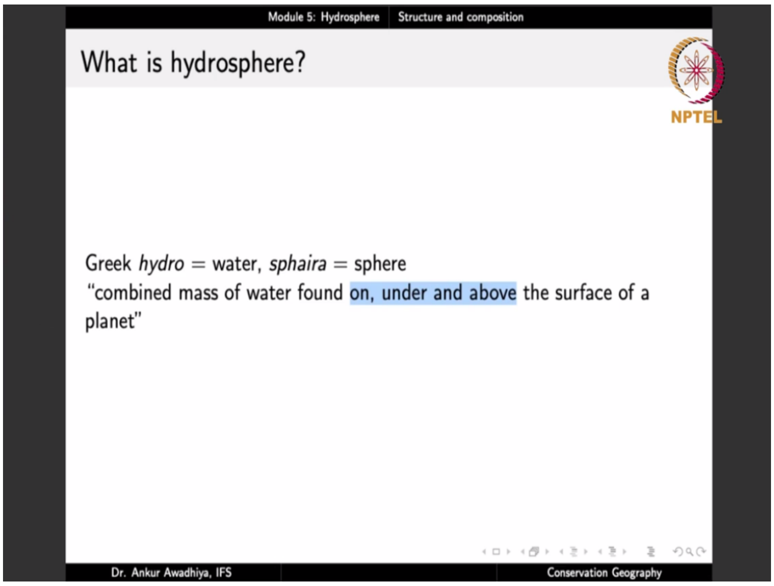

So, hydrosphere the term comes from the Greek terms hydro meaning water and is sphaira meaning a sphere. So, this is the watery sphere, we can define it as the combined mass of water found on under and above the surface of a planet on, under and above. So, what are the waters that we are talking about? When we talk about water on the surface of a planet, we are talking about things such as oceans, seas, rivers, rivulets, channels, streams, lakes, ponds, marshes, and so on.

So, all the water that is there on the surface of the planet, but hydrosphere also includes water that is under the surface of the planet, meaning that we are talking about groundwater and it also includes the water that is above the surface of the planet, meaning that we are talking about water that is present in the form of water vapor in the atmosphere. So, that too be include as part of the hydrosphere. So, hydrosphere is the combined mass of water found on, under and above the surface of a planet.

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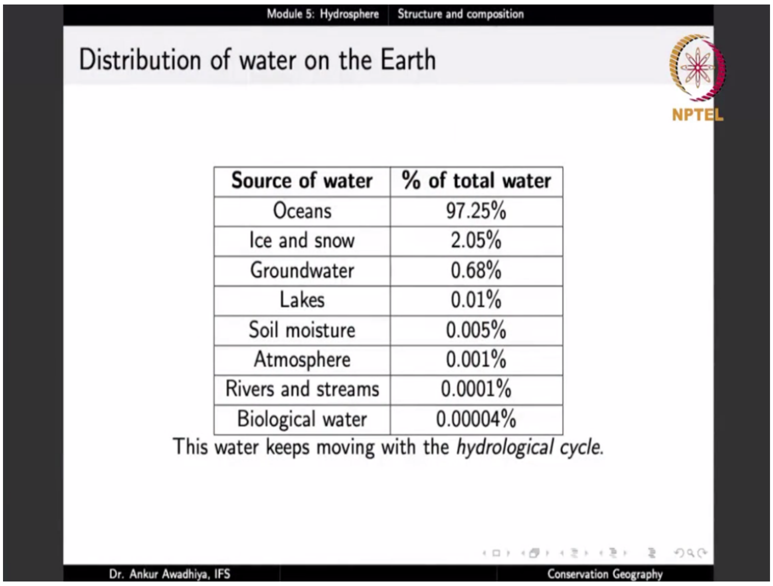

Now, on the Earth, the distribution of the water is like this 97.25 percent of all water is there in the oceans. So, oceans are the biggest component of the hydrosphere. Around 97.25 percent of all the water. Around 2 percent is in the form of ice and snow, especially the ice and snow in the glaciers and ice and snow in the permafrost regions, those regions that are covered with snow and ice all around the year typically near the poles.

So, that comprises around 2 percent of all the water. 0.68 percent of water is groundwater. So, this is the third major component. And then we have everything else, lakes 0.01 percent, soil moisture 0.005 percent, atmosphere 0.001 percent, rivers and streams 0.0001 percent and biological water that is water that is present in the living beings, the plants and animals. So that is 0.00004 percent.

And all of this water is moving at all times, it moves with the hydrological cycle or the water cycle. So water cycle is a cycle that moves water between all of these different components of the hydrosphere.

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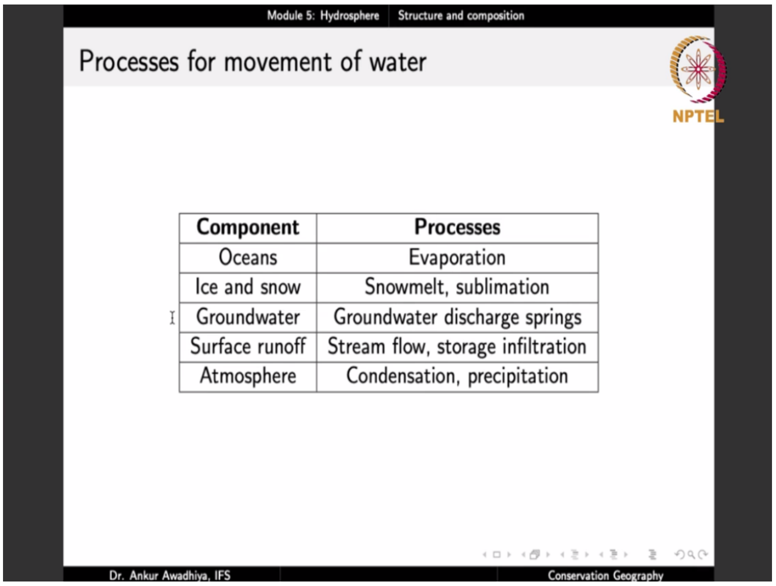

And how does this water move, there are several processes. In the case of oceans, the water can leave the oceans through evaporation. So in the process of evaporation because of heat, water gets converted into water vapor and it moves into the atmosphere. From the ice and snow components we can have snow melt, so in which case the ice and snow are converting into liquid water or we can have sublimation where the ice and snow are converting directly into a gas which is the water vapor.

From the groundwater, water can reach to the surface through groundwater discharged springs, the surface runoff or the water that is there on the surface, it can move in the form of a stream flow or it can get into the groundwater through storage infiltration. So, with the steam flow, this surface runoff will move into the oceans and through story infiltration, this water will move into the groundwater.

In the case of atmosphere, the primary processes are condensation and precipitation. So, when water vapor condenses, it forms liquid water, which then falls down to the Earth through the process of precipitation. Now, these are the major processes, there are a number of other processes in each of these components. So, for instance, the surface runoff can also get evaporated but that is a very small fraction when we talk about the surface runoff. In the case of the ocean water, some part of it may seep into the groundwater but that, again is a small component. So, these are the major processes that move the water.

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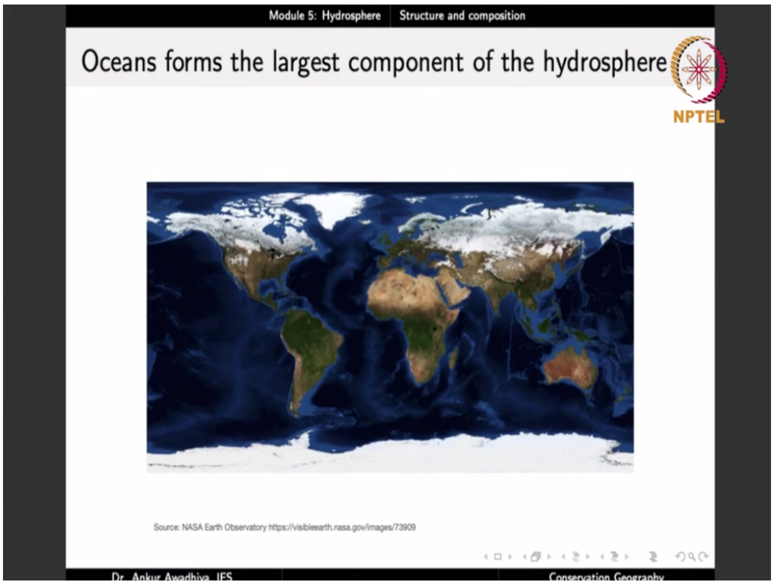

Now, we have observed that oceans formed the largest component of the hydrosphere. Around 70 percent of the Earth's surface is covered with oceans. So, when we talk about hydrosphere, it makes sense to give the lion's chunk or the lion's share of our attention to the water in the oceans. So this is what we are going to do now.

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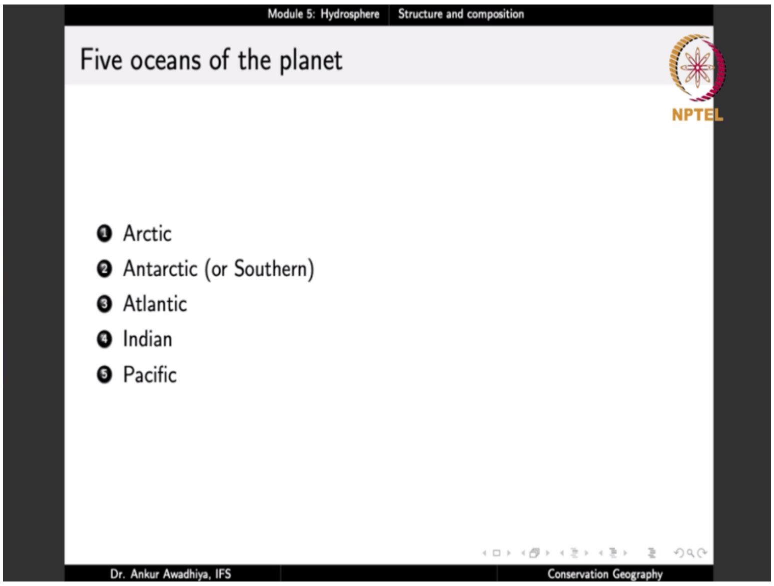

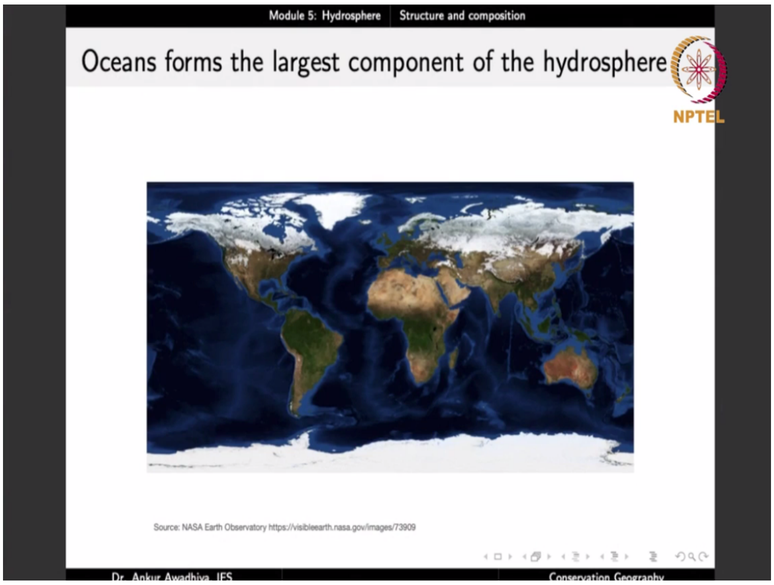

There are five oceans on the planet, we have the Arctic Ocean, the Antarctic ocean, or the Southern Ocean, Atlantic Ocean, Indian Ocean and Pacific Ocean. So near the North Pole, this region has the Arctic Ocean, this region has the Antarctic Ocean or the Southern Ocean. Near India, we have the Indian Ocean. Here we have the Atlantic Ocean, and this portion is the Pacific Ocean.

Now in this context, it is important to remember that there are nothing or no sharp boundaries that define where an ocean begins or ends. So these are just artificial differences or distinctions that we are making. So there is no line that separates the Indian Ocean from Atlantic Ocean, or the Atlantic Ocean from the Pacific Ocean, the waters are continuous.

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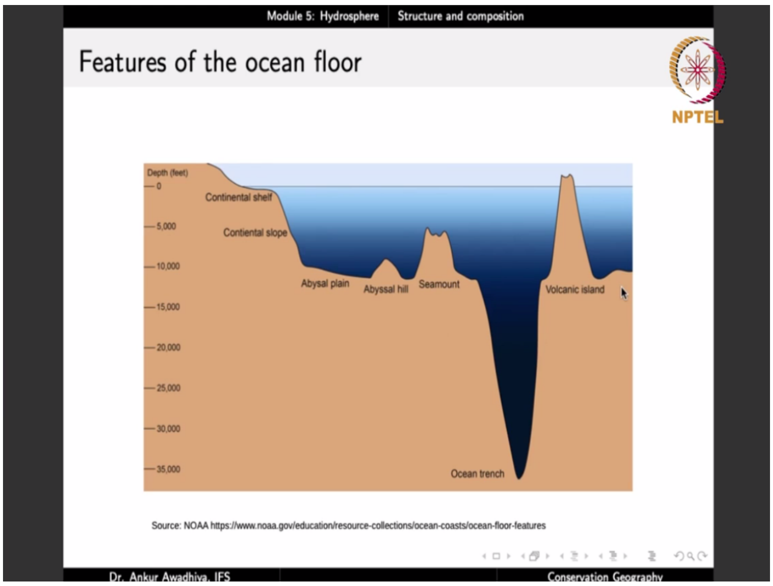

And when we talk about the oceans, we need to also talk about the ocean floor. Now what is below the surface of the oceans? It is not just a flatland, there are a number of features. And these features play a role in the movement of waters. So we have things like the Continental shelf, the Continental slope, the Abyssal plains, the Abyssal hills, Seamounts, Ocean trenches, Volcanic islands, and a number of other features.

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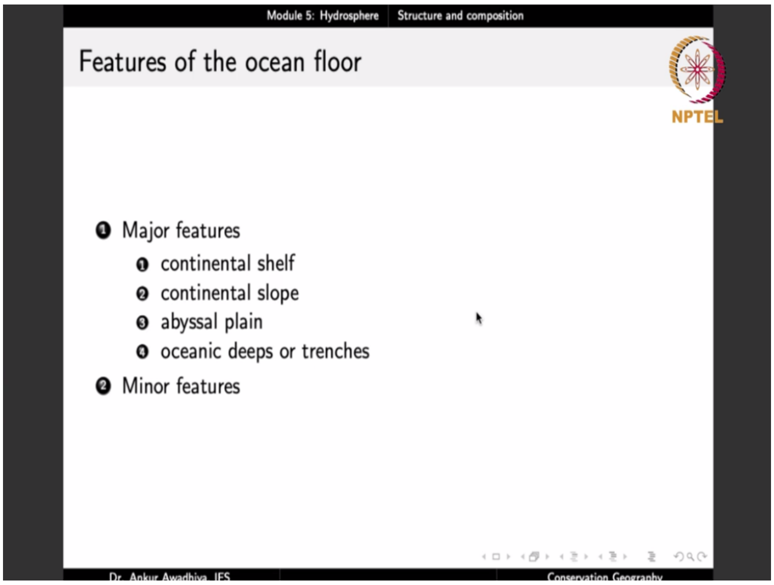

And of these features, we divide them into two categories. We have the major features and the minor features. The major features include continental shelf, continental slope, abyssal plain, and oceanic deeps or trenches. So let us now look at all of these.

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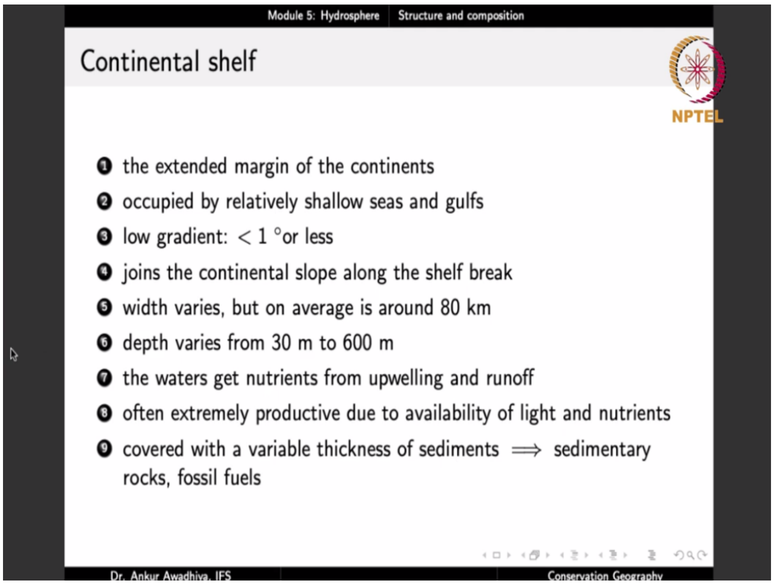

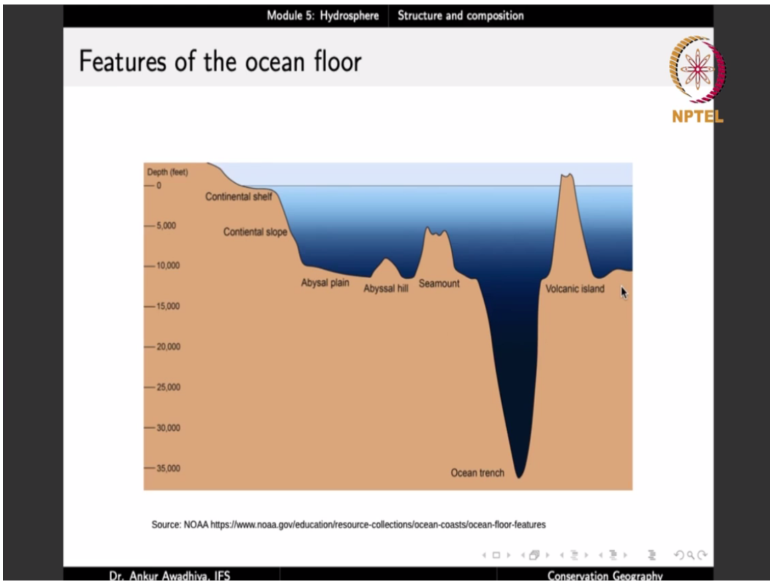

Continental shelf is the extended margin of the continents. So when we talk about an ocean, the ocean is right next to a landmass which is the continent. Now the extension of the continent below the water of the oceans is the continental shelf. It is the extended margin of the continents occupied by relatively shallow seas and gulfs.

So its depth is not very high. It has a low gradient which means that it has a low slope less than one degrees. It joins the continental slope along the shelf break. So, if this is the shelf, this is the slope, this portion will be known as the shelf break. The width varies, but on an average it is around 80 kilometers.

So this is a portion of the continent that goes below the surface of the oceans up to around 80 kilometers. The depth varies from 30 meters to around 600 meters. The waters get nutrients from upwelling and runoff. Now in this portion, here in the continental shelf, you have water at a, of a less depth and also you get quite a lot of nutrients. And we get nutrients through two means.

One is runoff, which means that the rivers that are draining into the ocean, they are carrying sediments and they are carrying nutrients. So that nutrient is made available for the organisms that are living in the continental shelf. At the same time, we also have the process of upwelling. So, what is upwelling?

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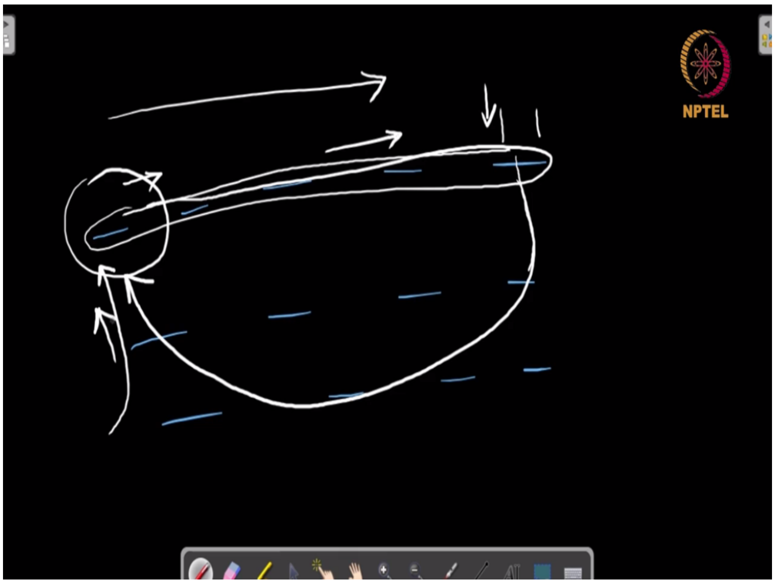

When we talk about a mass of water and when you have a moment of winds, so, you have strong winds that are moving like this. So, what this wind would do is that it would take away the top portion of this water and it would concentrate it on this side. So, essentially, you are having more water that is deposited is that is getting deposited here and water from this portion it is moving away. Now, when that happens, the water from the below it can rise upwards.

So, you can have a cyclical moment of water like this. So, wind is shifting the water from this point to this point, and then because you have an excess of water here the water column increases in height, because of which it exerts a pressure and now the water moves down and this cyclical in the cyclical manner the water can move. So, at these locations, you have water that is coming up from below. So these are the regions that are known as upwelling regions.

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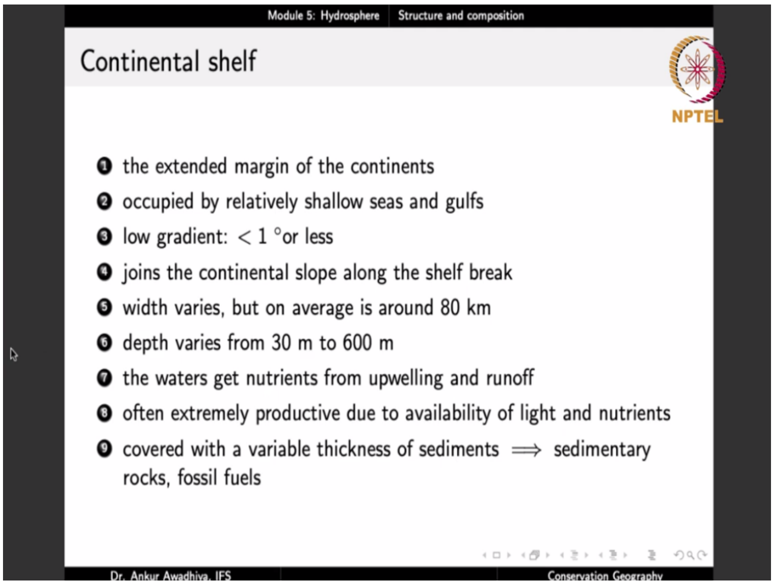

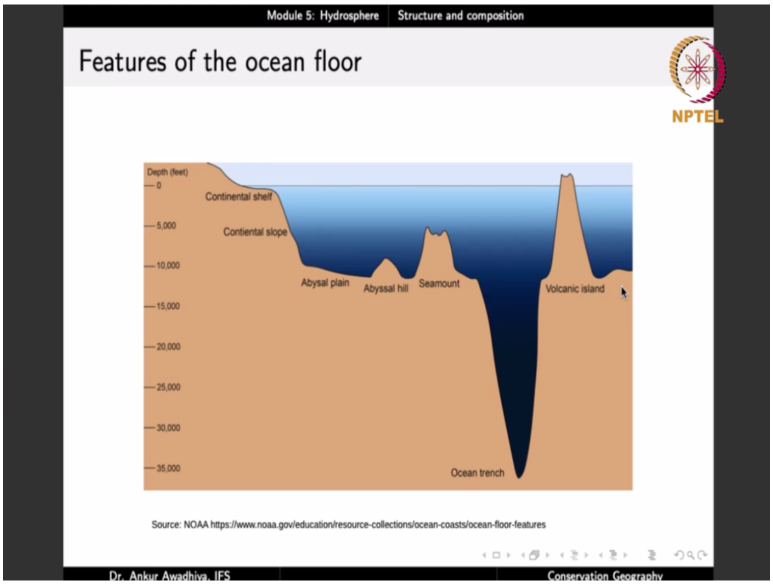

Similarly, we can also have a situation in which when we have this situation, and you have the continental shelf, followed by the continental slope, if there is an ocean current that is moving like this. So the waters in the current they will move along with this slope, reach into the shelf, and here again you are getting water from the below. Now typically what happens in an oceanic system is that when organisms die, they start to sink.

So when organisms die, the major chunks will be eaten up by sort by certain other organisms. But whatever remains in the form of decomposed or partly decomposed fragments, it will go on settling down. So typically, the water that is deep down in the oceans, it is having a larger amount of nutrients than the water that is there on the top. Now through the process of upwelling, this nutrient rich water is made available to the top layers of the ocean.

Now the problem with the bottom layers is that the oceans are so deep, that sunlight does not reach to the bottom of the oceans. And so even though you have nutrients, you will not have a large amount of photosynthetic activity, there is hardly any light available there. And so all of that nutrient rich water is stored. Whereas on the top layers, you have a lot of sunlight, but you do not have the nutrients or the minerals that are necessary for the growth of plants and planktons.

So through the process of upwelling, what happens is that the nutrient rich water from deep down, it comes to the surface and there, the plants and the planktons can make use of the nutrients and they also have sufficient sunlight. So they will do photosynthesis and convert it into food for all the organisms in the ocean.

So the ocean, the continental shelf, it gets nutrients from upwelling and runoff. And it is often extremely productive, because light is available since the depth is less and nutrients are also made available through upwelling and runoff. So when it is extremely productive, it means that there is lot of photosynthetic activity, lot of food gets made. And because you have a lot of food, it will also support a lot of organisms. So a very large number of fishes and other aquatic organisms can be found in the continental shelves.

The continental shelf is covered with a variable thickness of sediments. Now these sediments are being brought through the runoff process. So when the rivers are draining into the ocean, they are bringing the sediments with them. Now these sediments are going to settle in the continental shelf. Now, along with the sediments that the rivers are bringing, you also have the organisms that are living there when they die, their bodies also are settling down in partly decomposed or decomposed fashions, and so you are getting a lot of sediments.

And these sediments settle down and you get a layer of variable thickness. So in certain areas, especially those that are near the mouth of rivers, you have a very thick layer of sediments. In far off areas you have a thinner layer of sediments. Now, because you are having sediments here, so these are very good locations where sedimentary rocks can be formed.

And because you have ample amount of organisms here and the rivers are also bringing in dead bodies of several organisms, so you also get a lot of fossils in these areas. So, these are the areas where sedimentary rocks and fossils can be formed. And over time you can even have good deposits of fossil fuels. So, this is the continental shelf.

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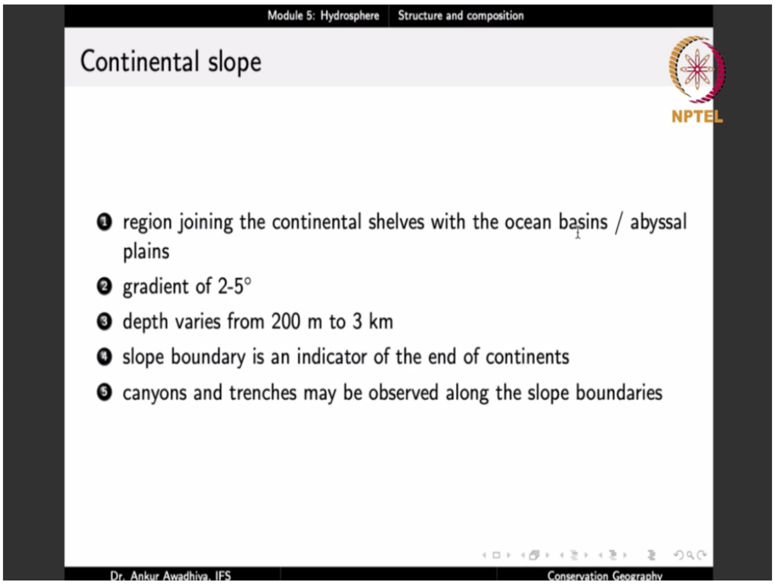

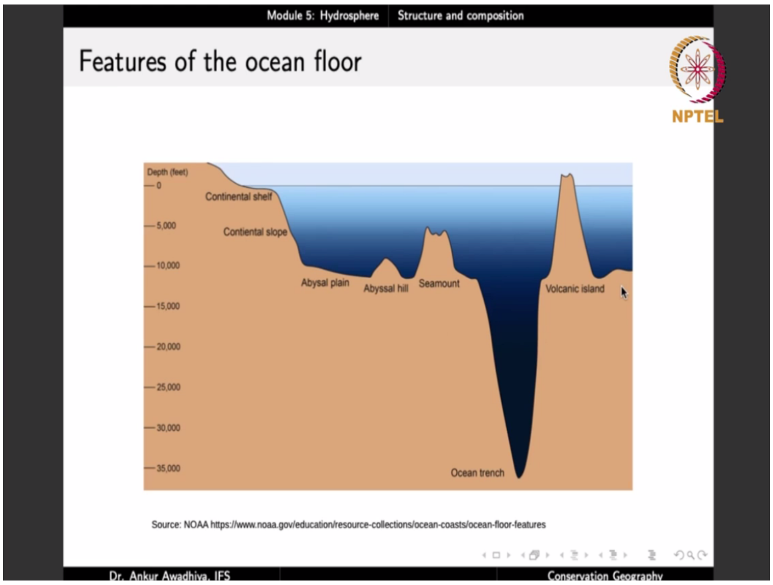

It is followed by the continental slope. The continental slope is the region that joins the continental shelf with the ocean basin or the abyssal plain. What we are saying is on one side you will be having continental shelf on the other side you will be having an abyssal plain. So the region that is joining this is the continental slope. And as you can observe from this figure, it is called as continental slope because its slope is very high. It is not like the continental shelf.

When we say shelf, it means that it is more or less a level poor land. So less than one degree of slope. But in the case of continental slope, the slopes are very high, the gradient is high between 2 to 5 degrees. The depth varies from 200 meters to up to 3 kilometers. The slope boundary is an indicator of the end of the continents. So, when we talk about this point, this is where we can say that the continent is ending.

The canyons and the trenches may be observed along the slope boundaries. So you can have certain geomorphological features such as canyons and trenches. We will have a look at it in a short while. So, that is the continental slope.

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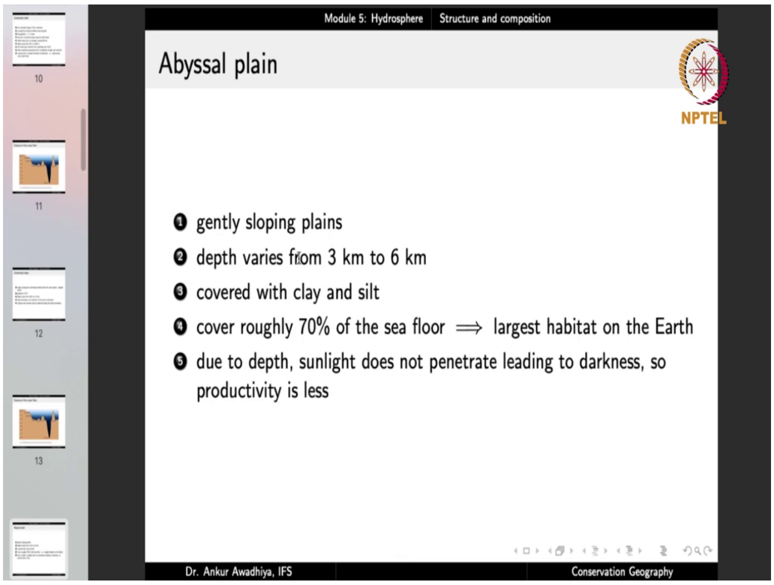

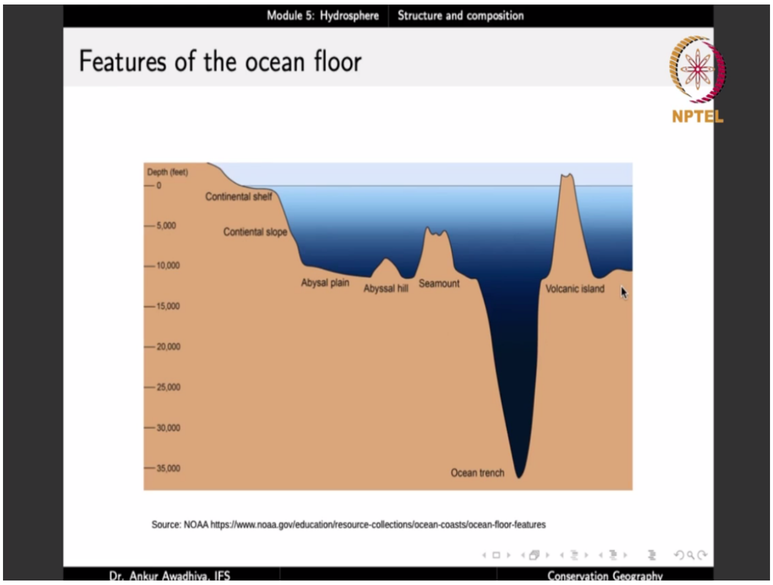

Next we have the Abyssal plain. It is a plain because it is a gently sloping area. So these are gently sloping plains and they are abyssal which means they are at a depth. The depth varies from 3 to 6 kilometers covered with clay and silt. So what are these plains covered off, they are covered with clay and silt that is settling in these areas. Now remember that when the sediments are brought by the rivers into the oceans, the larger size sediments they will be deposited in the continental shelf.

And the more finer sediments will be taken away to larger distances, because they take a lot of time to settle down. Which is why in the case of the abyssal plains, you will mostly find clay and silt that are small in size and so they remain suspended for long. They cover roughly 70 percent of the sea floor. And so they are the largest habitats on the Earth. Because the oceans themselves cover around 70 percent of the planet and they are covering 70 percent of the 70 percent.

So, roughly around 49 percent of the Earth is comprised of abyssal planes. So, these are the largest habitats that are found on the planet. Now, due to their depth, sunlight does not penetrate leading to darkness and so the productivity is less. So, they are very much like deserts in the ocean. So, you have nutrients, but you do not have a large number of organisms that live in these areas. So, these are vast expanses with little, little amount of life very similar to our deserts. So that is the abyssal plain.

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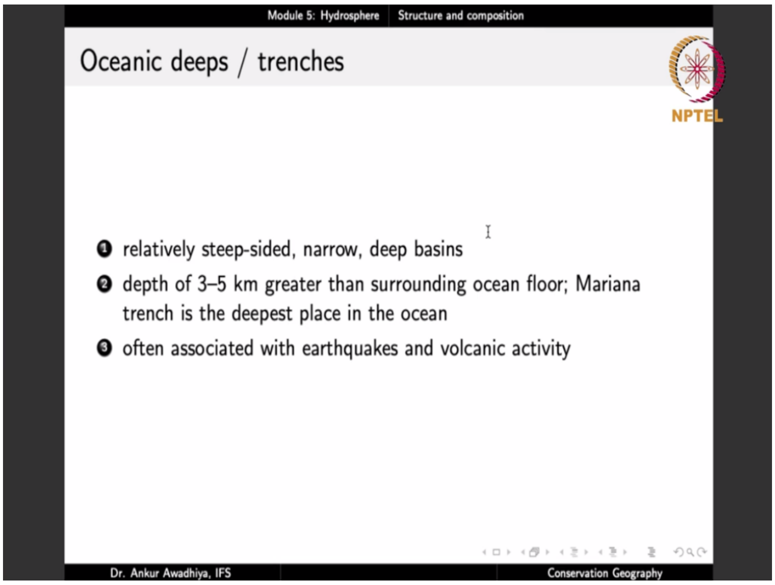

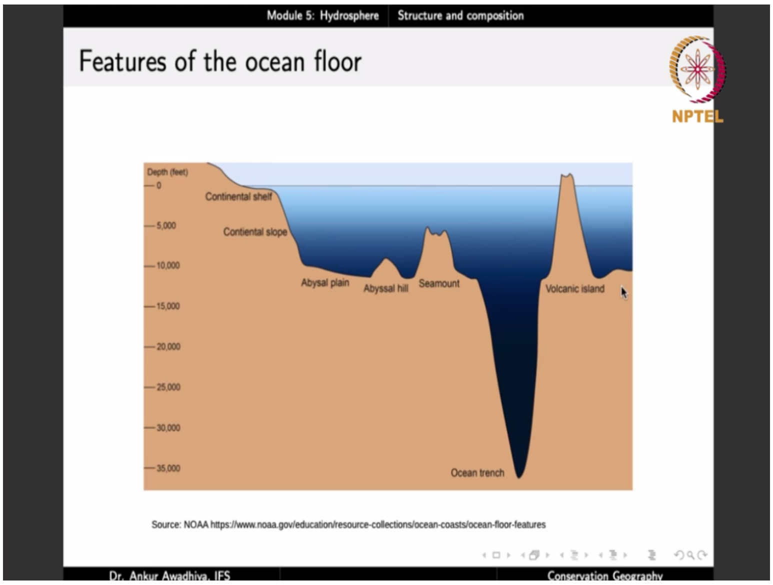

Next we have Oceanic deeps and trenches. These are relatively steep sided, narrow, deep basins. They are steep sided, so this is a trench. So these are steep sided, these are very deep and these are typically also narrow. So, if we look here, so the width here is less, the depth is very high. So this is a very narrow trench.

The depths are 3 to 5 kilometers greater than the surrounding ocean floor. And Mariana trench is the deepest place in the ocean. These are often associated with earthquakes and volcanic activity. So these trenches are often formed because there is certain tectonic movement that is going on in the area. So these are the oceanic trenches.

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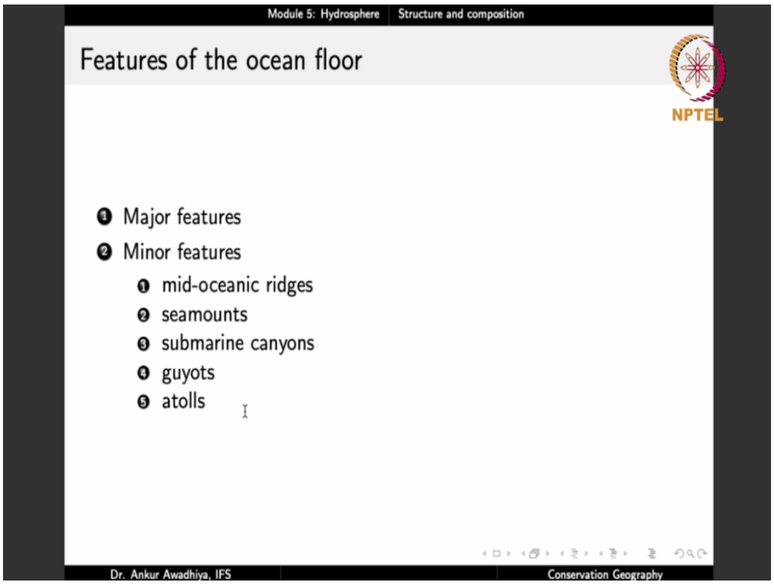

We also have a number of minor features of which mid oceanic ridges, seamounts, submarine canyons, guyots and atolls are more important.

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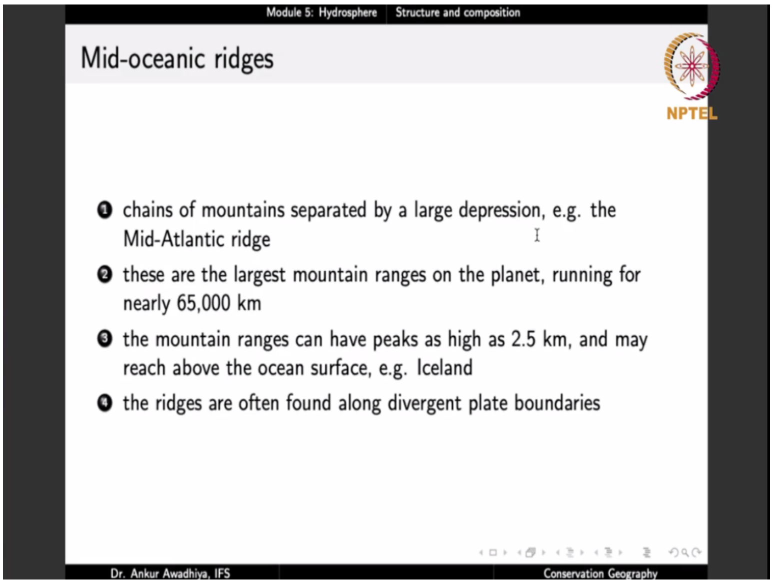

Now we have already looked at mid oceanic ridges before so they are the chains of mountains that are separated by a large depression, such as the Mid Atlantic ridge. So it is a chain of mountains. And these are the largest mountain ranges on the planet running for roughly 65,000 kilometers. The mountain ranges can have peaks as high as 2.5 kilometers and may reach above the surface of the ocean. For example, Iceland is a part of the mountain ridges.

And the ridges are often found along with divergent plate boundaries. We have observed this before, when we were talking about plate tectonics, that you have these Mid Atlantic ridges and that oceanic ridges, where you are having divergent plates, so the plates are moving away from each other and oceanic crust is getting created in these regions. So, how do these mid oceanic ridges look like?

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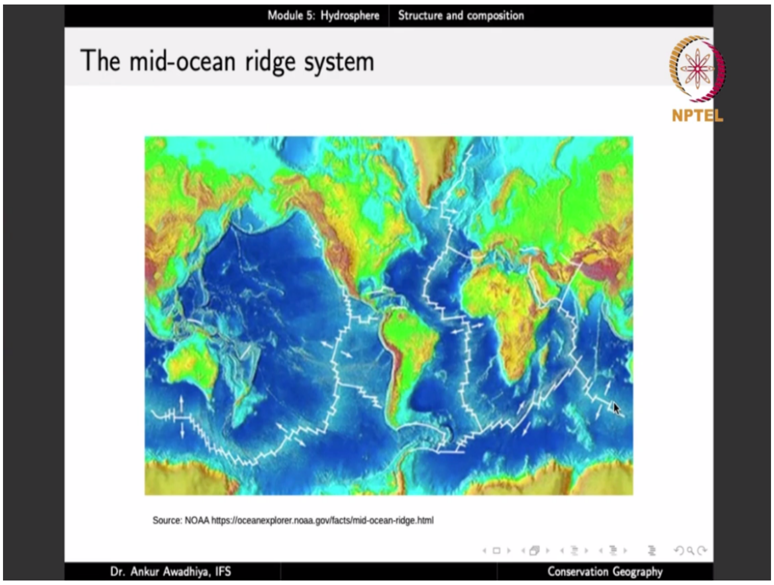

So, this is a map and you can observe that these are roughly all over the planet. So there are for 65000 kilometers.

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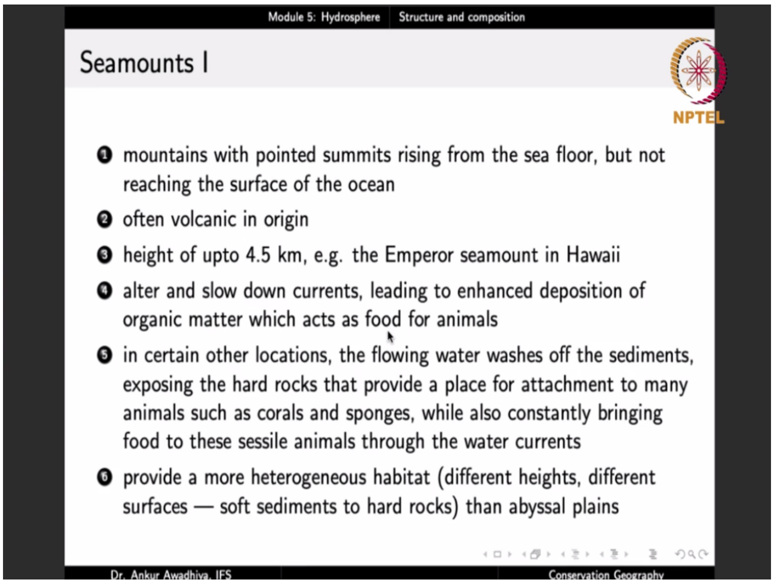

Then we have the Seamounts. So these are mountains in the sea. So mountains with pointed summits rising from the sea floor, but not reaching the surface of the ocean. If they reach the surface they become islands if they do not reach we call them Seamounts or Sea mountains. They are often volcanic in origin similar to our composite volcanoes can reach a height of up to 4.5 kilometers such as the Emperor seamount in Hawaii. And they alter and slow down currents leading to enhance deposition of organic matter which acts as food for the animals.

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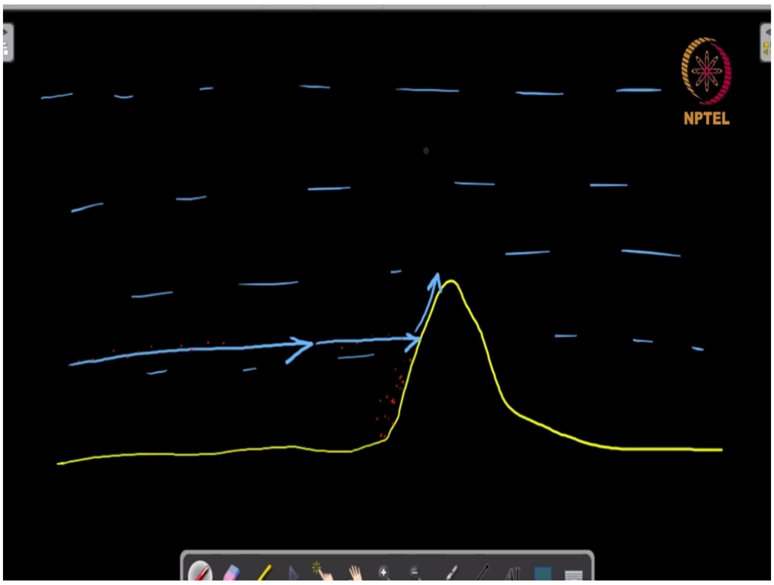

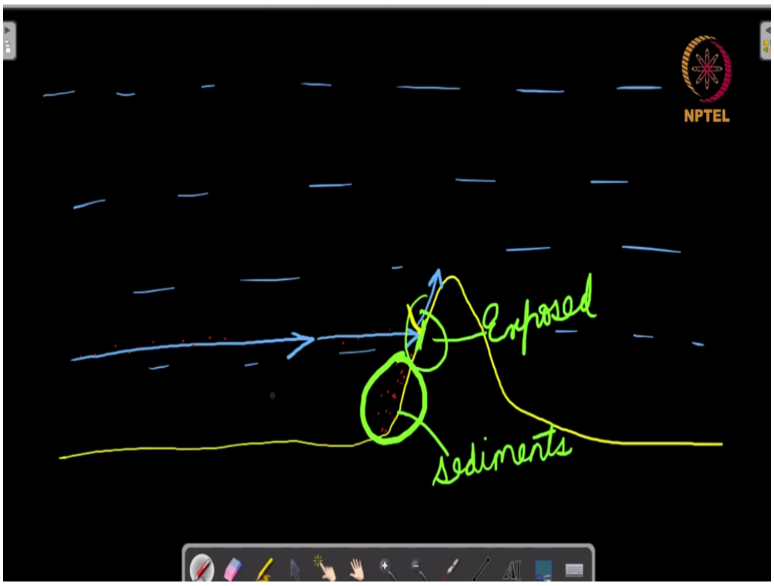

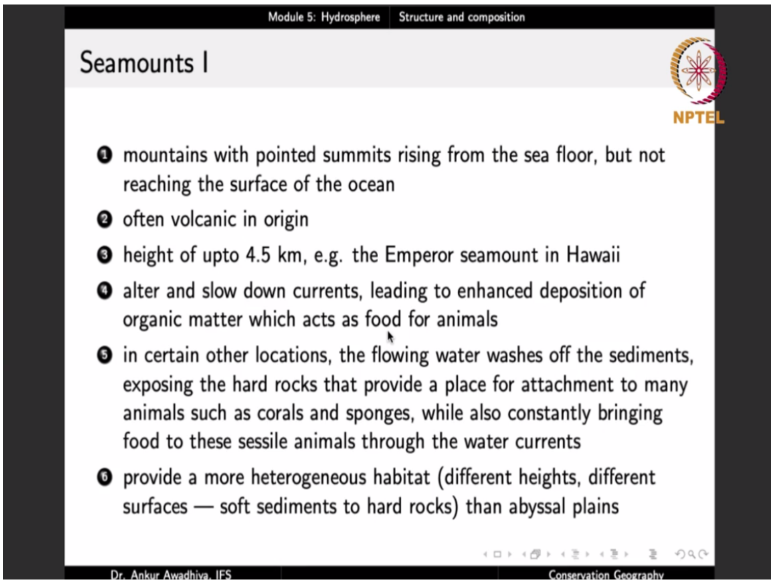

So, what we are saying here is that if you have these abyssal planes and then there is a mountain and all of this region is deep below the ocean surface. Now, in this case, if you have an ocean current that is moving like this, so the ocean currents will carry with it certain sediments now, when this ocean current meets the seamount, so, there is an abrupt stoppage or there is a deflection of this ocean current.

So two things can happen one, it can be stopped or the speed reduces, and two, it gets deflected upwards. Now when this speed reduces, the ability of this current to carry the sediments also reduces, which leads to the deposition of these sediments here. And two, if it moves upwards, then it is leading to an upwelling. So these are two things that the seamounts do; one, they lead to deposition of sediments, and two, they lead to upwelling.

Now, when they slow down the currents, there is enhanced deposition of organic matter. And this matter can act as food for animals. So they typically support a larger amount of animal life as compared to the abyssal plains. And in certain other locations, the flowing water washes off the sediments, exposing the hard rocks that provide a place for attachment for many animals, such as corals and sponges, while also constantly bringing food to these sessile animals through the water currents.

So what we are saying here is that at these locations, where the oceanic currents collide with the seamounts, you will not find a much deposition of sediments, because this water that is moving at a high speed, it is washing it away. So in these locations, you have hard rocks that get exposed. And a number of organisms that are attaching organisms, they can attach themselves to these hard rocks. So in this case, what we find is that you have certain areas in the seamounts that have abundant amount of sediments, and certain other areas that are exposed.

So you can have different kinds of organisms that are supported in these two different areas. Certain organisms that require sediments to live, they can live in the sediment rich areas, and certain other organisms that require a hard rock to attach themselves to and live in the exposed areas. Now if the animals attach themselves to these exposed areas, so if you have an animal here, the other good thing is that this animal will always be getting food because of the oceanic currents that we will be bringing different sediments and different organic matter that can be used as food.

These sessile animals because these animals are attached they cannot move, but still because the water is moving so they are constantly getting food. They provide a more heterogeneous habitat. Because you have habitats at different heights, different surfaces, from soft sediments to hard rocks, then the abyssal plains.

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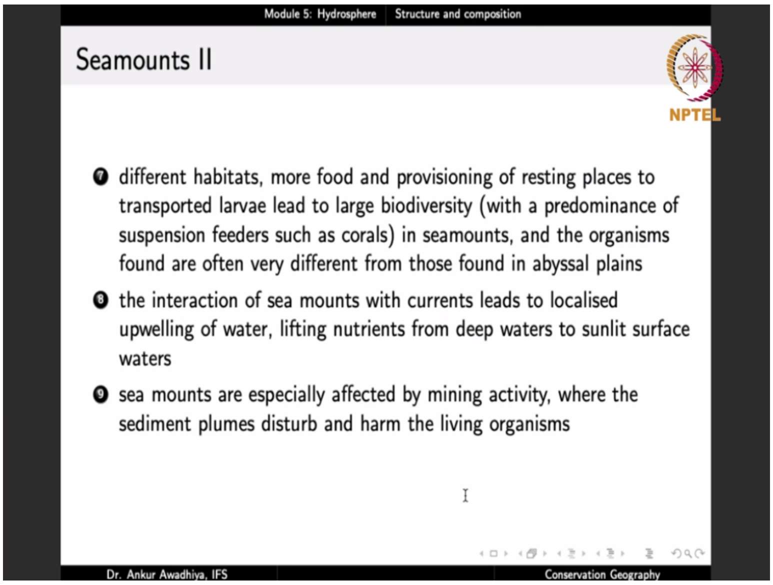

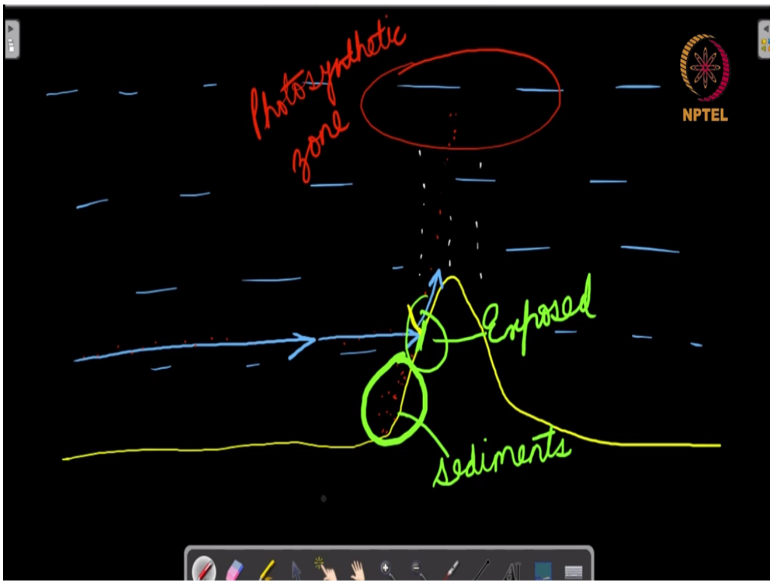

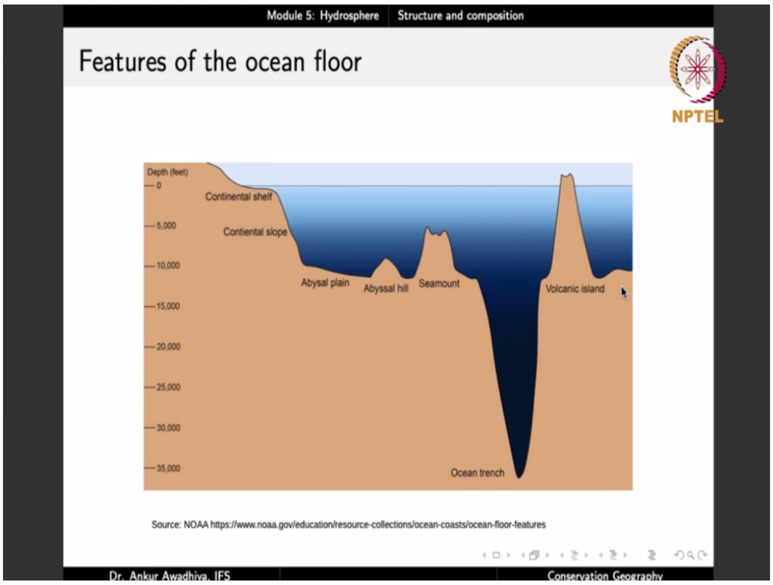

And these different habitats, more food and provisioning of resting places to transport it larvae lead to a large biodiversity in these areas with a predominance of suspension feeders, such as corals in the seamounts and the organisms found are often very different from those found in the abyssal plains, because the habitat is different. So, it supports a very different biodiversity as compared to the abyssal plains.

So, you have different habitats, varied habitats, also lots of food. And so, you have a large variety of organisms that are formed. The interaction of seamounts with the currents leads to localized upwelling of water, lifting nutrients from deep waters to sunlight surface waters.

And when this happens, when the nutrients are being pushed upwards, then what happens in this region, you have a photosynthetic zone. Because in these locations, you have abundant amount of sunlight, and you are also getting these nutrients from these oceanic currents. And so, you will have a lot of food production that goes on in this area.

Now, what will happen to all this food, when these organisms die, they will either be eaten away by the other organisms or else they will settle down. And when they settle down, where will they settle down? They will settle down on this seamount. So, this is another source of nutrients that is made available for the animals that live on the seamounts.

So essentially, they are extremely rich in biodiversity. They are like the oasis in our deserts. But because you have a lot of organisms, it also means that there is a lot of possibility to harm them. Seamounts are especially affected by mining activity, where the sediment plumes disturb and harm the living organisms. So whenever we are doing a mining in the oceans, and typically mining is done for things such as manganese nodules.

So, if this mining has to go on, in any case, in that case, we should be careful that mining is not permitted near the seamounts, or else these oases in the deserts they themselves will be lost and with them all the organisms that live there will also be lost. So they are very important from the point of view of conservation. So this is a seamount.

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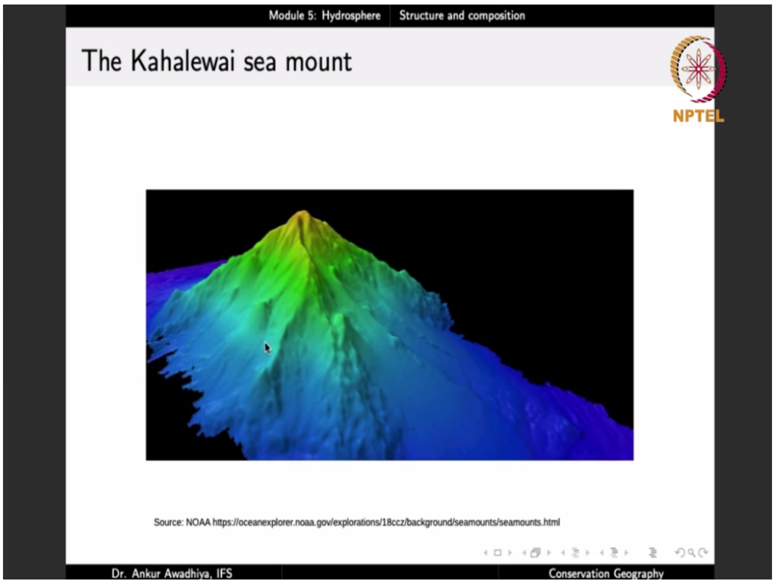

This is how a seamount looks like so this is the Kahalewai seamount.

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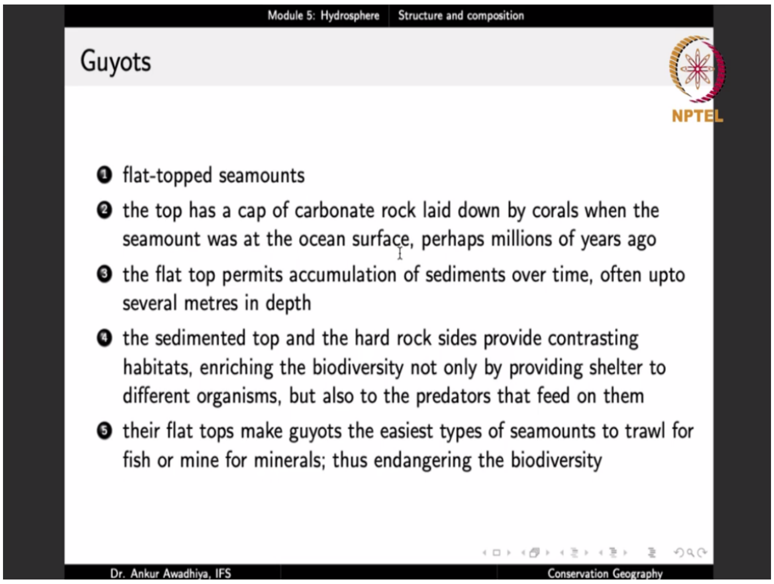

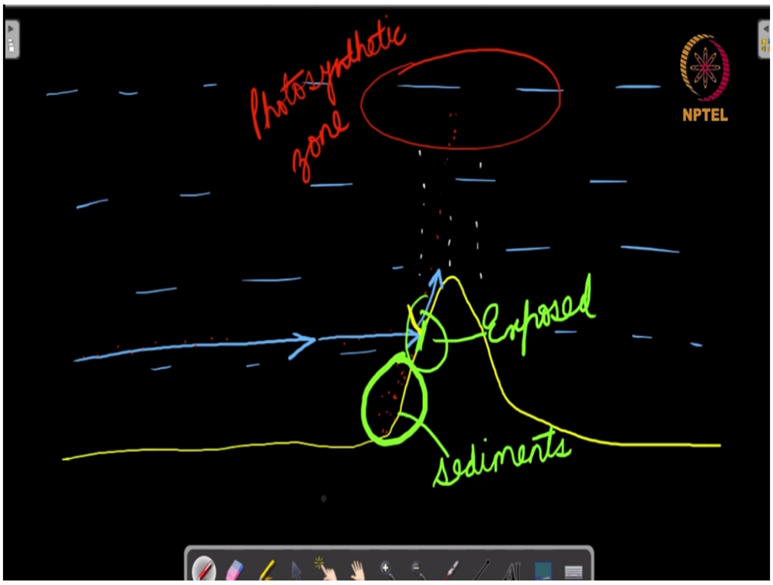

Next we have the Guyots. Guyots are flat topped seamounts. So they are very similar to the plateaus that we have on the lithosphere. So a plateau is a hill with a flat top. And similarly we have the guyots below the water. The top has a cap of carbonate rock that is laid down by corals when the seamount was at the ocean surface perhaps millions of years ago. What does that mean?

Well, basically, when we talk about global warming, what is happening is that more and more amount of carbon dioxide in the atmosphere is leading to an enhanced greenhouse effect, because of which the ice caps are melting and water is moving into the oceans raising the sea level.

Now think about this process in reverse. When the planet cools down, then more and more water starts getting stored in the ice caps because any precipitation in those areas any snowfall in that area will not be melted and so the ice caps start growing in size. When that happens, the sea level falls. And we can observe a large number of examples, where the sea levels have changed over geological time scales.

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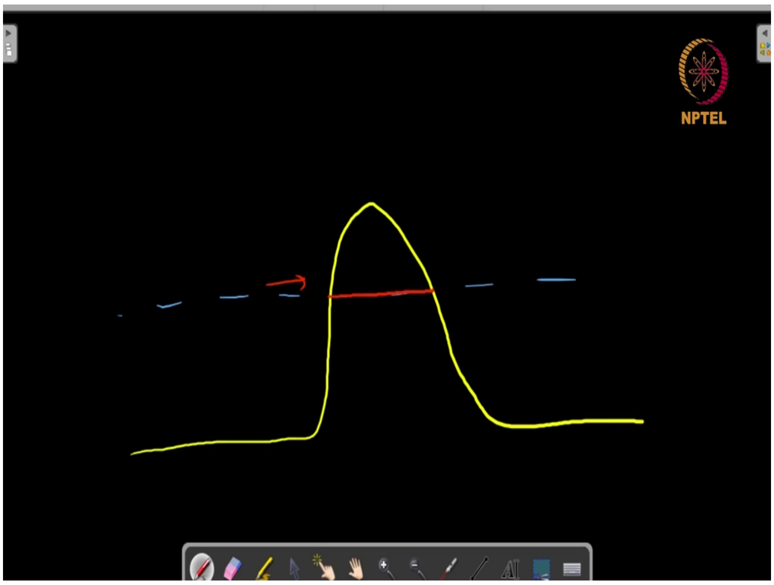

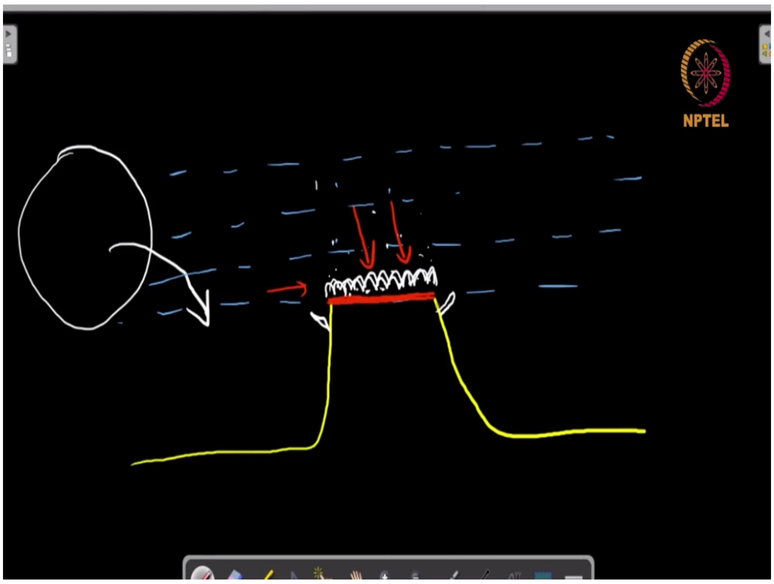

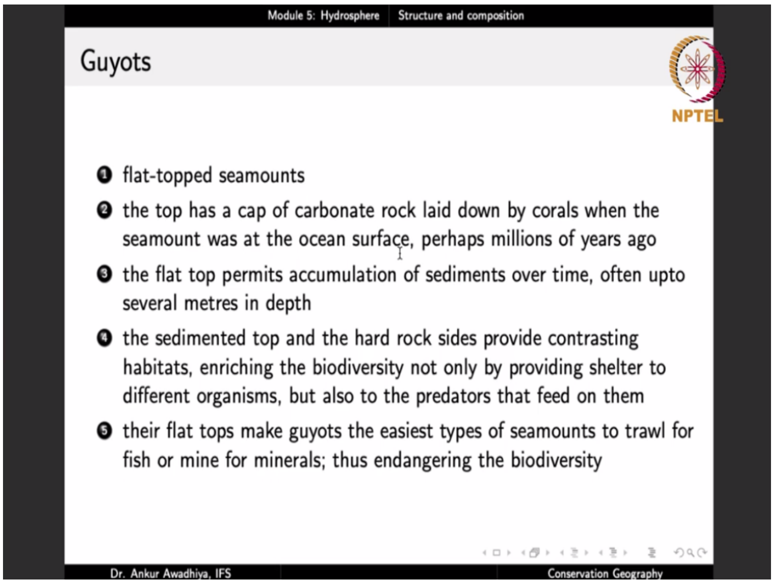

So, earlier, if you had the sea level, say at this level and in those days, suppose there was a seamount that rose to the surface in that case what would happen. Now, on the surface of the sea, you have the sea waves and these sea waves would be colliding against the top of this mountain and essentially they will lead to erosion so that this top becomes a flat area. So in that case, the seamount would get this flat top.

Now this happened when the sea levels were less. Later on when, when the planet starts to warm up, you have water that moves from the snow caps from the polar ice caps into the ocean and so the water level begins to rise. So, now this is the water level. When that happens, this top portion of the flat top mountain, it now becomes an extremely productive zone because you have abundant amount of sunlight and you also have a surface on which various organisms can attach themselves. And typically, you will find a large amount of coral growth in this area.

Now corals as we have observed, they have an exoskeleton that is made up of calcium compounds. And so you have a lot of calcium deposition that goes on here. When the corals die their exoskeletons remain, and so you have a lot of calcium in this area, then later on, when the planet warms even further, this portion raises even further and then there will be a time after which this portion or the seamounts will have become so deep that it is now no longer able to support the corals. So now we do not find corals here on the top, but we still have a top cap of calcium compounds.

Mostly carbonates. So the top has a cap of carbonate rocks laid down by corals when the seamount was at the ocean surface perhaps millions of years ago. And this flat top permits the accumulation of sediments over time, often up to several meters in depth. So what happens now if there is any sedimentation in this area, because you have a flat top with lots of carbonates, so the sediments are able to accumulate in this areas.

And so you have a layer of sediments, even several meters in depth. The sedimented top and the hard rock sides provide contrasting habitats enriching the biodiversity not only by providing shelter to different organisms, but also to the predators that feed on them. So now, once you have a layer of sediments on the top, you can have sediment dwelling organisms, and on the sides you can have say those organisms that prefer living on hard rocks. So here again you have a differentiated habitat because of which you can have a greater amount of biodiversity. The flat tops may be guyots, the easiest types of seamounts to trawl for fish or mine for minerals.

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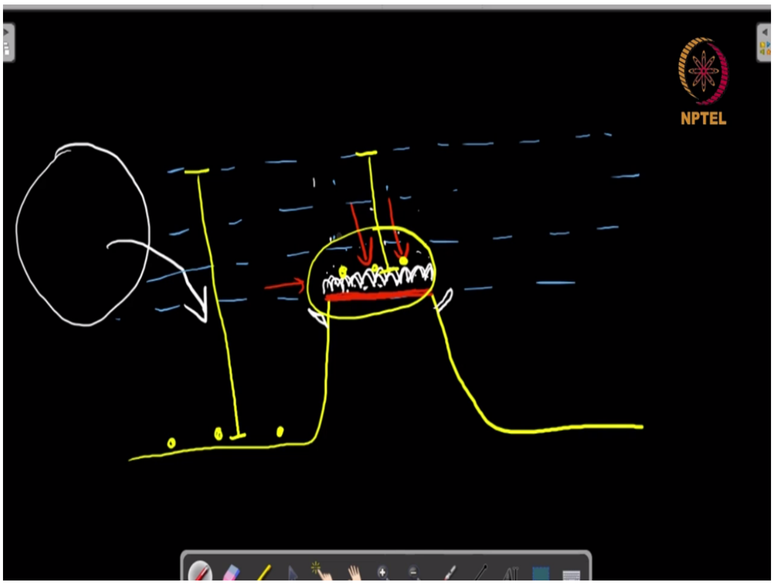

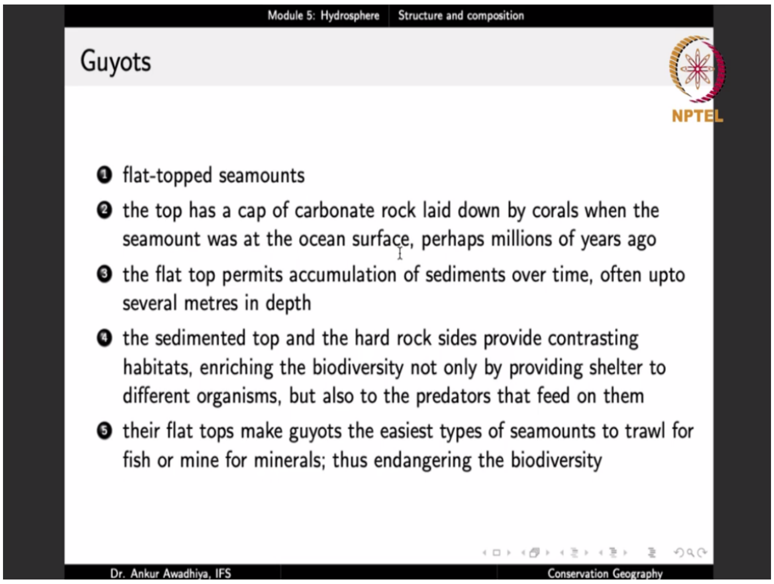

Now here comes the conservation challenge, because if you wanted to mine for say manganese nodules here, in that case, you have to bring these nodules from this depth. But if there are manganese nodules here, you only have to bring them from this depth. And so the guyots are heavily mined. At the same time, because you have an abundance of food in this area, you also have a lot of fishes in these areas.

And these areas being flat top, it is easier for trawlers to access them. So if you trawl these areas, your nets will not be entangled to something and so they are heavily trawled. And with both of these activities, mining and trawling, there is a very great amount of destruction to the biodiversity that is happening in the guyots. So these are the easiest types of seamounts to trawl for fish or mine for minerals does endangering the biodiversity.

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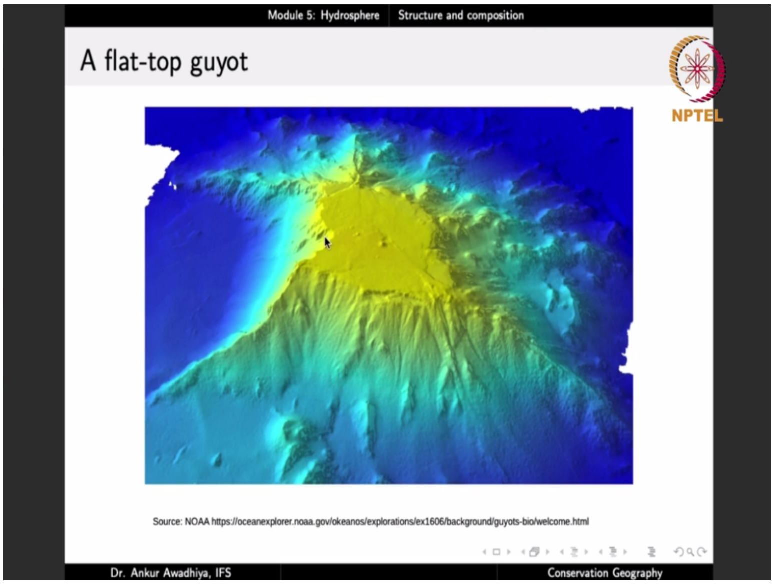

This is how a flat top guyot looks like. So you can observe that this was essentially a seamount, but with its top that is cut off.

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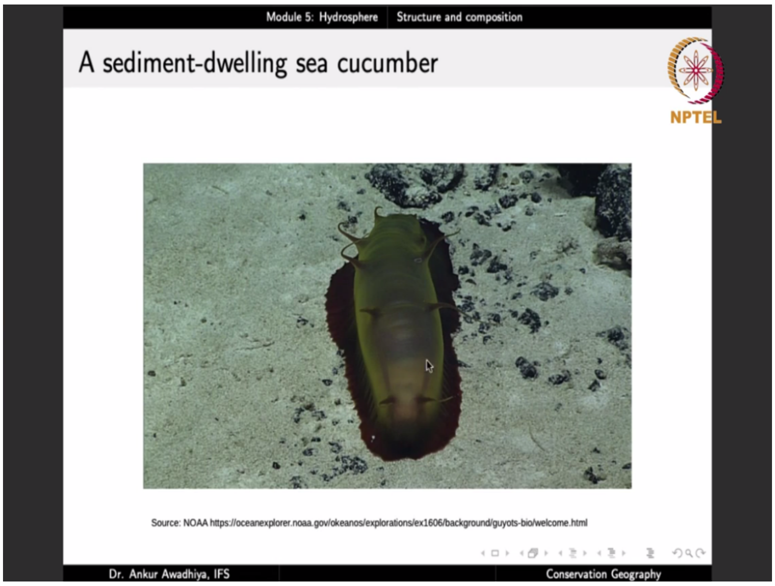

These are the kinds of organisms that we find there are sediment-dwelling sea cucumber, which is living on the sediments on the top.

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You also have a sediment-dwelling shrimp. So these are some examples of the unique biodiversity that is found in the guyots.

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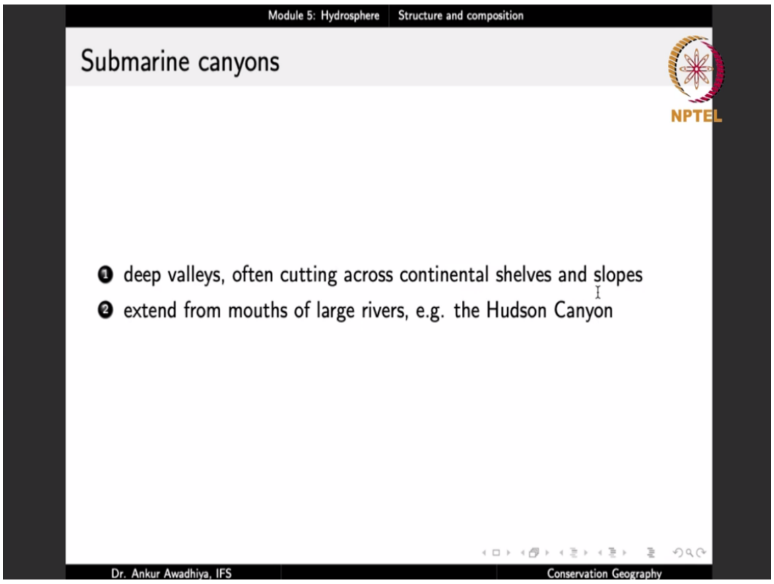

Another feature is the Submarine canyons. Now we had talked about canyons such as the Grand Canyon, which are deep valleys that are made by the erosional activity of rivers. Now similar to the canyons that we find on the lithosphere or on the land, we also have submarine canyons below the sea level. So these are deep valleys, often cutting across continental shelves and slopes and they extend from the mouth of large rivers such as the Hudson Canyon.

So, in this case, what is a submarine Canyon? It is an extension of the erosional activity of the river. So, once the river has reached into the seas, the very fast flow of water it continues to a distance. And in that process, it goes on eroding the continental shelf and the continental slope resulting in very similar features as the canyons that are found on the land.

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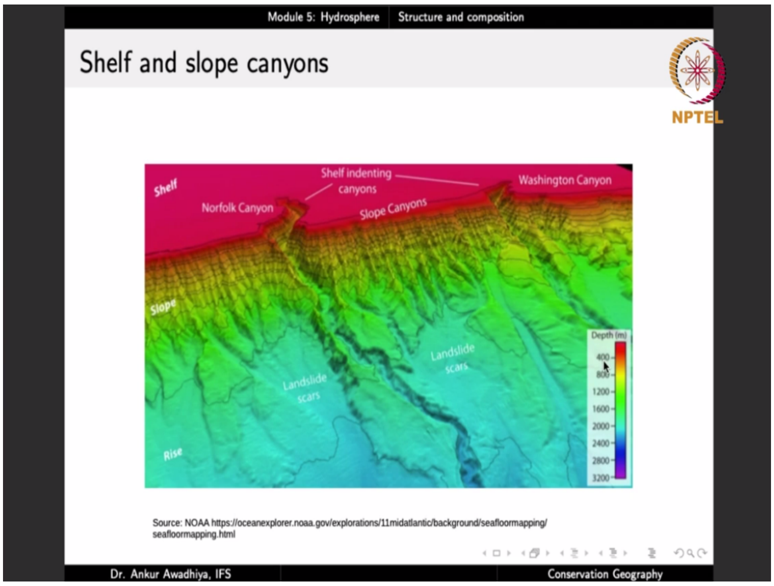

So, this is how it will look like. So, in this case, we have the continental shelf and the continental slope and we can find that these are very deep valleys that have been created.

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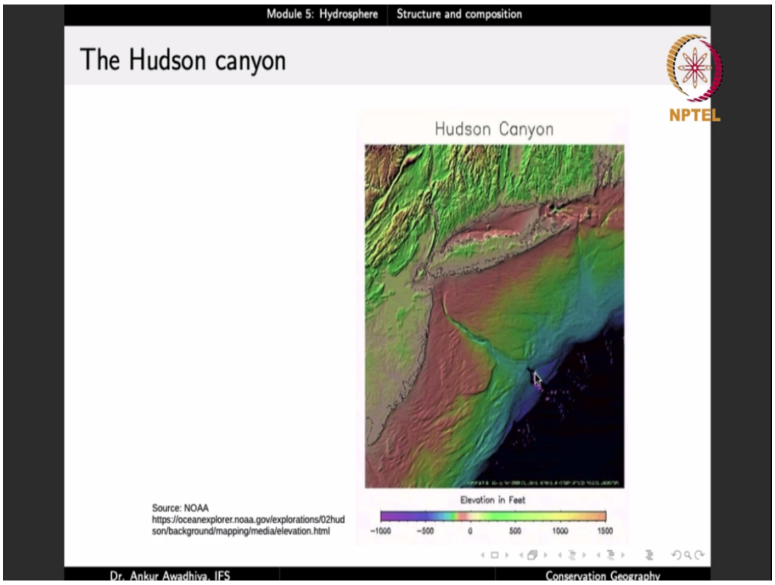

Now, when we talk about the Hudson Canyon, here, you are going to observe that this is 0 meters above sea level. So, this is the sea level, all these portions on the left they are below the sea level. So, these regions are below the sea level and the river ends here, but you are finding that there is a valley that has been created. So this is a Submarine canyon.

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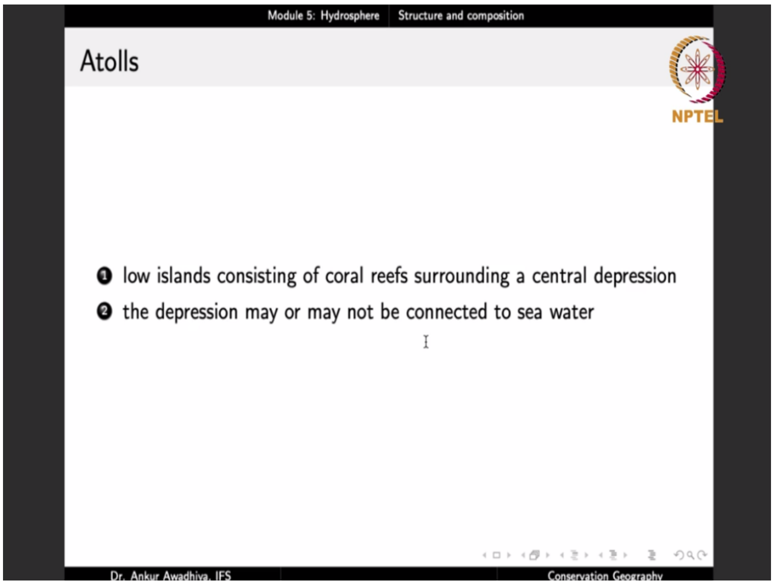

Another prominent feature is the Atolls. Atolls are low islands consisting of coral reefs surrounding a central depression. So, these are low islands, meaning that they do not have a very great height consisting of coral reefs that surround a central depression. So, they are primarily formed because of biological activity of coral reefs. The depressions may or may not be connected to the seawater.

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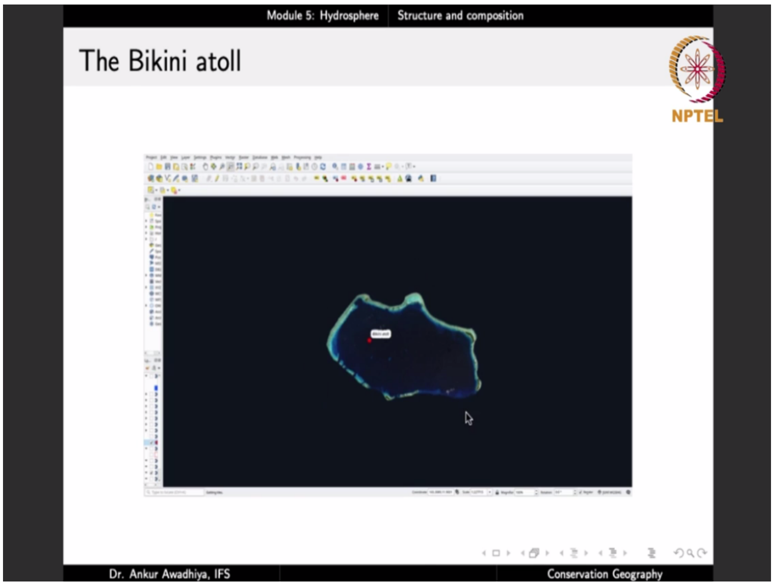

This is how an atoll looks like. So, this is a ring of corals, you have a sea in the center and you have the sea in the surroundings. Now, both of these seas are let us say that this is a lake. So this lake and the sea may be connected or they may not be connected. So this is an Atoll.

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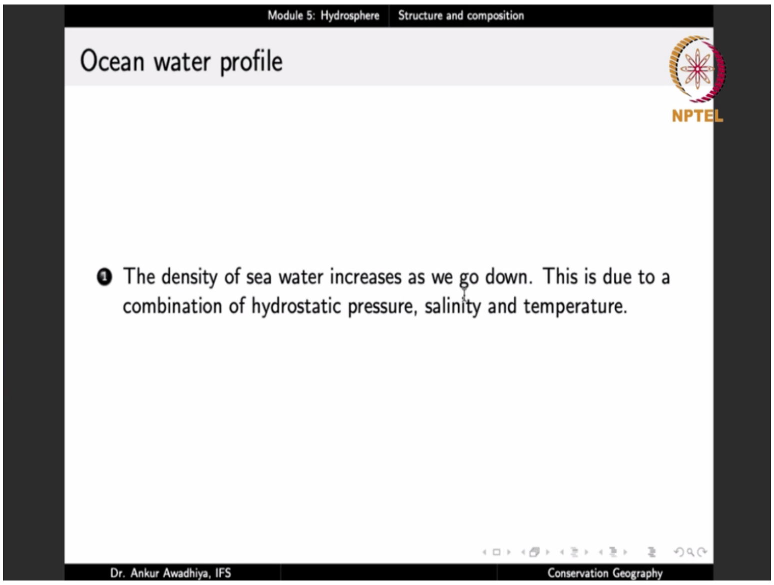

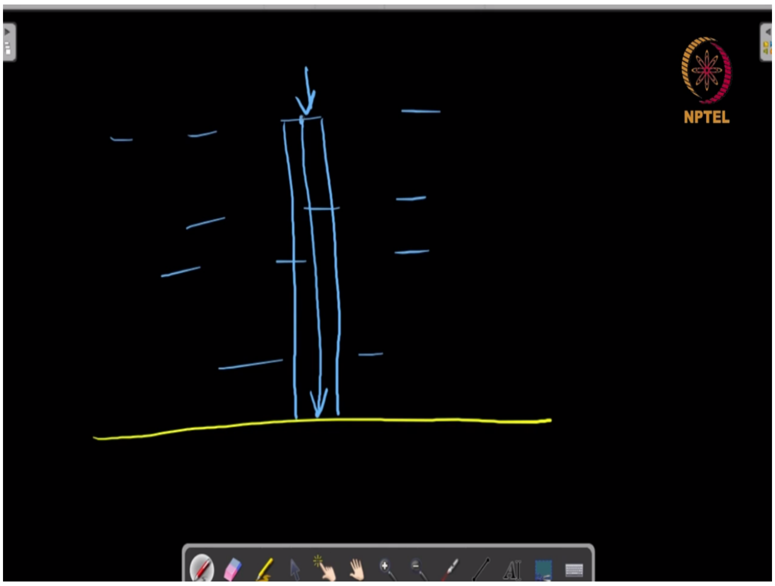

Now, along with the features, we can all also talk about the properties of the ocean water. And in this context, it is important to understand that the ocean water is found in different layers. So we can talk about the top layer, we can talk about the middle layers, we can talk about the bottom layer of the water column. And this creates a profile because these different layers have different properties. And that is known as the water profile.

The density of seawater increases as we go down, which is quite obvious because if you have denser water, it will typically sink to the bottom and the lighter waters will remain on the top. But why is the seawater denser in the bottom, it is because of a combination of hydrostatic pressure, meaning that the water in the bottom is being pushed by a large amount of water that is there on the top.

So in this case, if we consider a column, so the pressure at this point is primarily because of the weight of all of this water plus the atmospheric pressure at this point. So this results in a huge amount of pressure here, but the pressure at this point is equal to the atmospheric pressure. So the pressure increases with depth, which we have also observed before. Now water can be compressed to a very small extent. But with the increase in pressure, this compression increases the density of water. So that is one reason.

Second salinity the waters in the bottom of the ocean are typically more saline. And why are they more saline. This is because of a conveyor belt system in the oceans, we will have a look at it in a later lecture. But essentially what happens is that the water near the polar areas, when it freezes, the water gets converted into the ice and all the salts that were there in the water, because this is this being oceanic water or sea water it is rich in salts.

So the salts are left out in a process that is known as phase separation. And these waters move to the bottom of the ocean. So the salinity in the bottom is also high and third is temperature. The bottoms of the ocean are typically at around 4 degrees Celsius, at which temperature water has the highest density. So a combination of all these three forces means that the density of the water is highest at the bottom.

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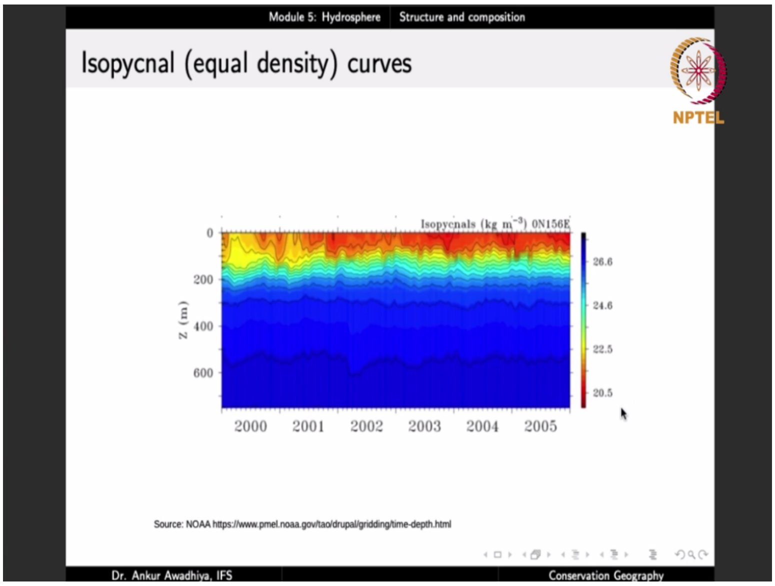

And if we draw isopycnal curves which is equal density curves, this is what it will look like. So, the bottom has here a density of greater than 26 kilogram per meter cube, whereas the top water has a density of around 20.5 kg per meter cube. So, the density increases as we move down.

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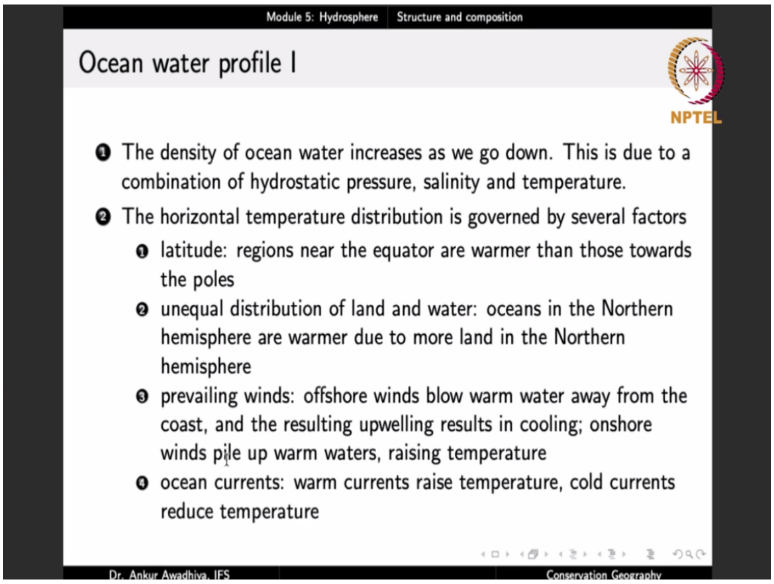

Then the horizontal temperature distribution is also different in different areas. So, now, we are talking about the temperature differences horizontally, meaning that in the same layer, what is the temperature in different locations and this is governed by the latitude, so the regions near the equator are warmer than those towards the poles we have seen this before. An unequal distribution of land and water, oceans in the Northern Hemisphere are warmer due to more land in the Northern Hemisphere.

Now, typically when we get sunshine, the land gets heated up much better and much quickly, much more quickly than the oceanic water and this heat is then channelized to the oceans. And so in the Northern Hemisphere because we have more amount of land, so the oceans also typically are warmer than those in the southern hemisphere. Then prevailing winds, offshore winds blow warm water away from the coast resulting in and the resulting upwelling results in cooling. Onshore water winds pile of warm waters raising the temperature.

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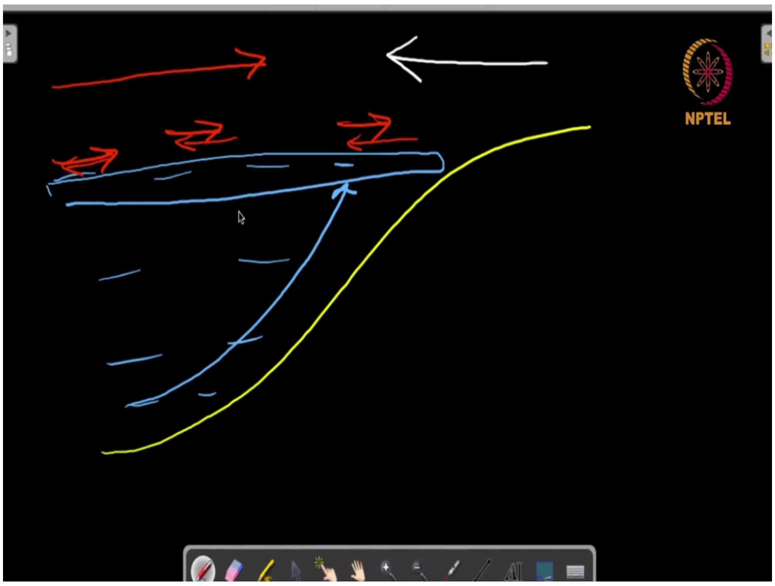

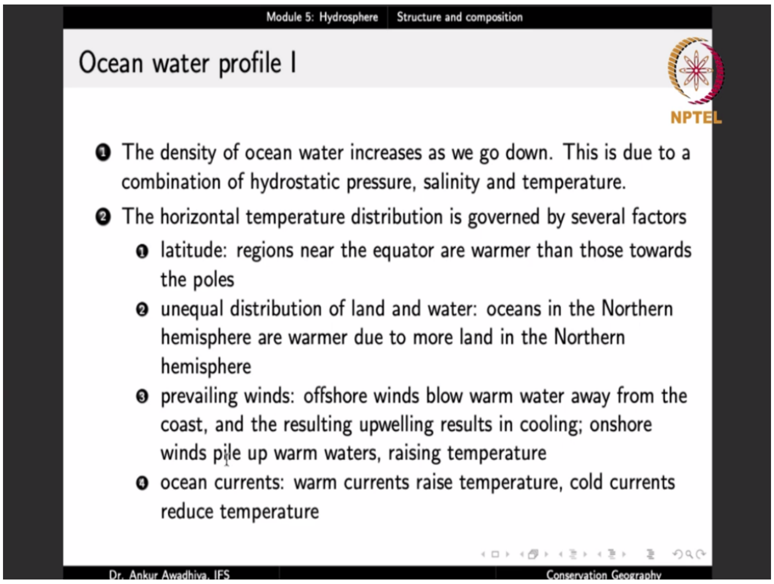

So what we are saying here is that if we consider this configuration now the top layer is generally warmer. And if you have winds that blow from the coast towards the ocean, what will happen is this warm water will be moved to far off locations. And when this warm water is moved away, the space that gets created here will be filled up by upwelling from the bottom. And so, winds that are moving towards the sea or towards the ocean, they result in a lowering of temperature of the sea surface.

On the other hand, if you have winds that are moving in the opposite direction, in that case, all of this water will be piled towards the sea coast. And so higher temperatures will be recorded in the sea surface. Then we have the role of ocean currents. If there are warm currents, they will raise the temperature if there are cold currents, they will reduce the temperature.

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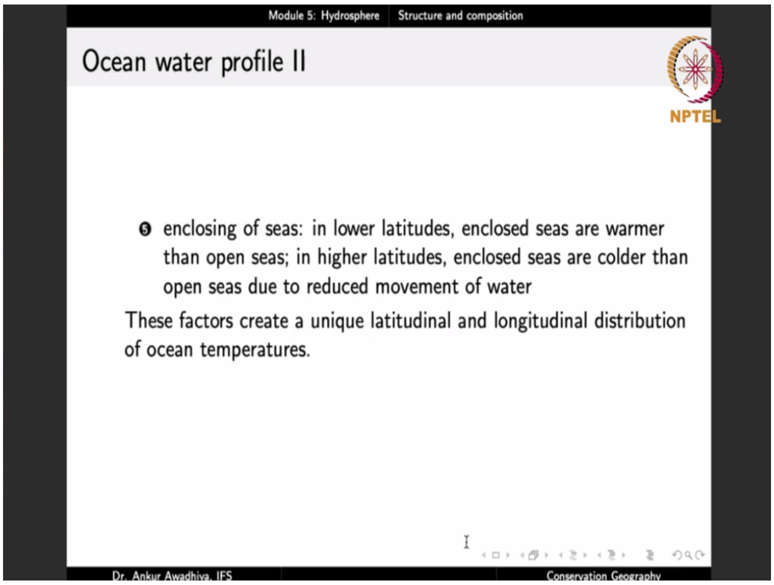

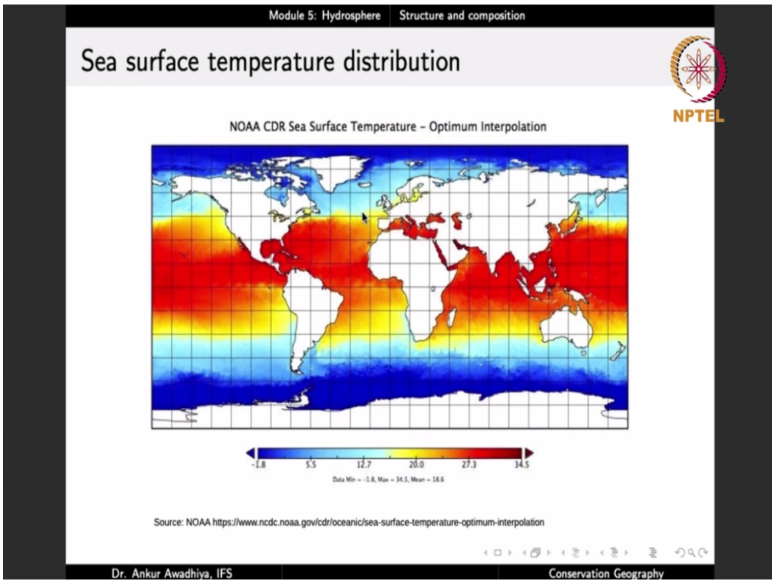

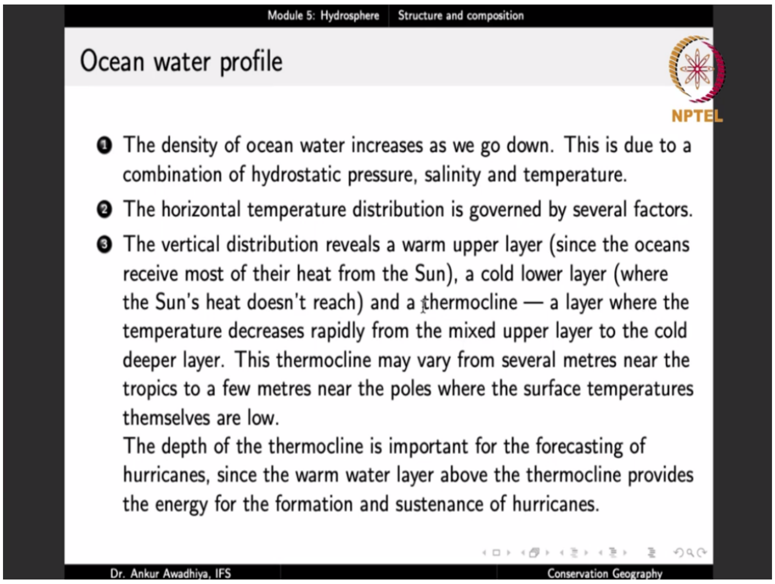

Then we also have the impact of enclosing of seas. In the case of enclosed seas that are surrounded by land from all side, we do not have a large movement of water. And so the temperatures will typically move towards the extremes. In the lower latitudes that is near the equator, the enclosed seas are warmer than the open seas. In higher latitudes that is near the poles, the enclosed seas are colder than the open seas due to a reduced movement of water. And these factors create a unique latitudinal and longitudinal distribution of ocean temperatures that looks like this.

So this is the sea surface temperature. And here you have the equator and it is easy to observe that in the northern hemisphere, it is more warmer in the southern hemisphere it is more cooler. And in the case of enclosed seas, you have a temperature that is greater than the open oceans in the same latitude. So this is the horizontal distribution of temperature.

The vertical distribution reveals a warm upper layer since the oceans received most of their heat from the Sun and a cold lower layer where the Sun's heat does not reach and a thermocline in between both of these layers.

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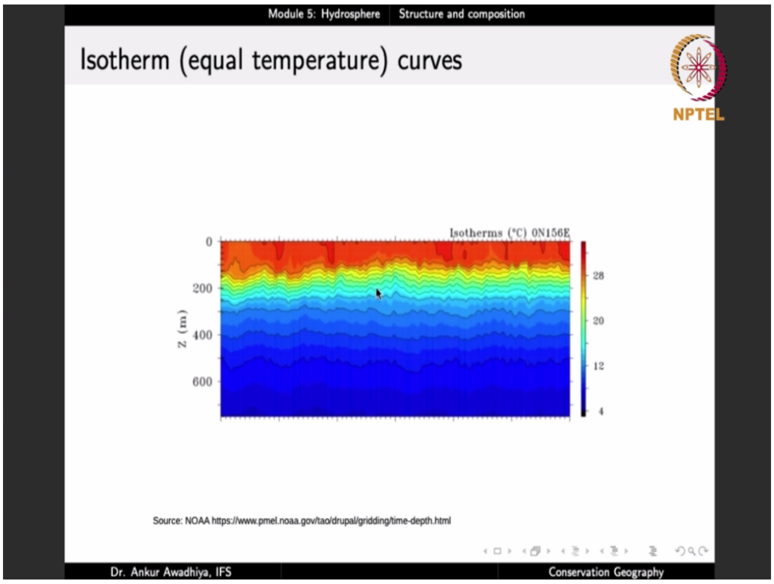

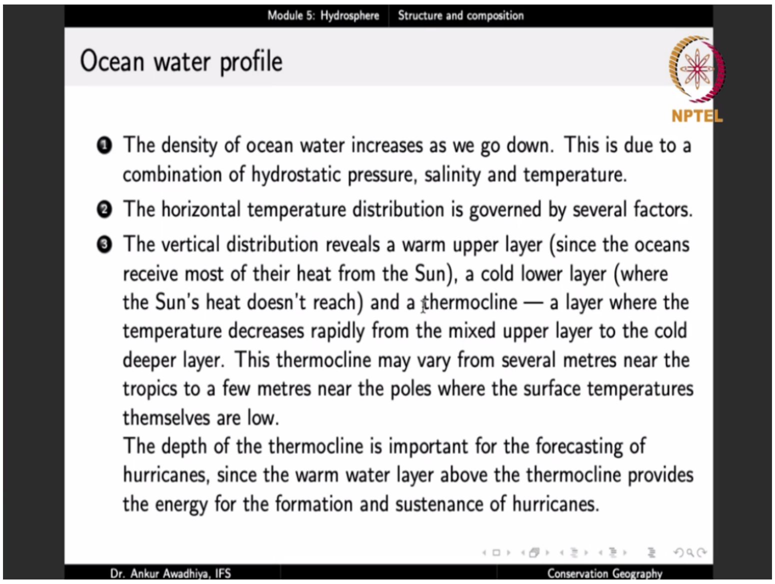

So the top layer is warmer, the bottom layer is colder and then in between you have a thermocline. Thermocline is a layer where the temperature decreases rapidly from the mixed upper layer to the cold deeper layer. This thermocline may vary from several meters near the tropics to a few meters near the poles, where the surface temperatures themselves are low. So when the surface temperature itself is low, then there is hardly any thermocline.

The depth of the thermocline is important for the forecasting of hurricanes and cyclones. Since the warm water layer about the thermocline provides the energy for the formation and sustenance of the hurricanes. So, we had observed this before in the case of cyclones, the tropical cyclones get most of their energy because of the heat and the condensation of water that occurs.

Now, the warm surface layer of the seas and oceans, it provides the energy for the formation and the sustenance of the cyclones. And so, if this warm upper layer is very deep or very thick, it would mean that there is a lot of energy that is available for the cyclones and in that case, cyclones will be formed much more easily and they will be much more severe.

On the other hand, if the thermocline is near the surface, it means that the upper layer of the seas is very thin, which means that not enough energy is available and so, either the cyclones will not be formed or if they are formed, they will not be that severe. So, this is the isotherm curves iso means same, therm is temperature. So, these are the curves that joint points at the same temperature. And here as well, we can observe that the top layer is warmer and the bottom layer is colder at around 4 degrees.

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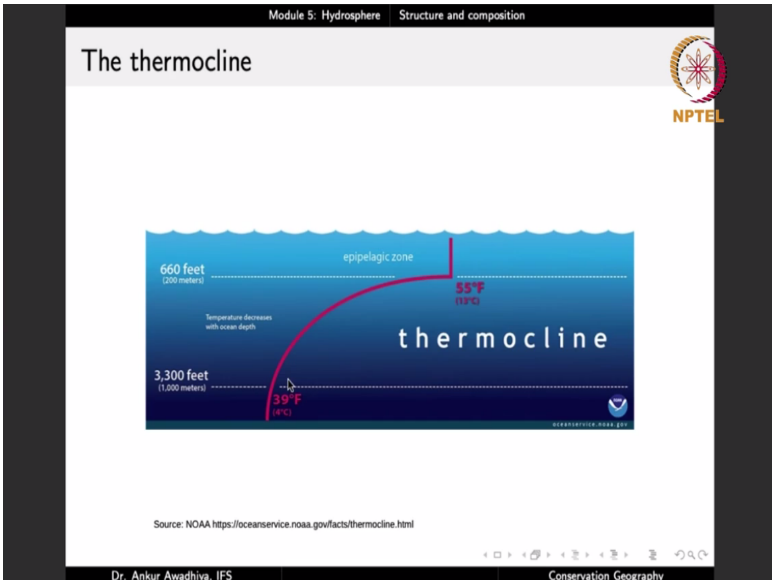

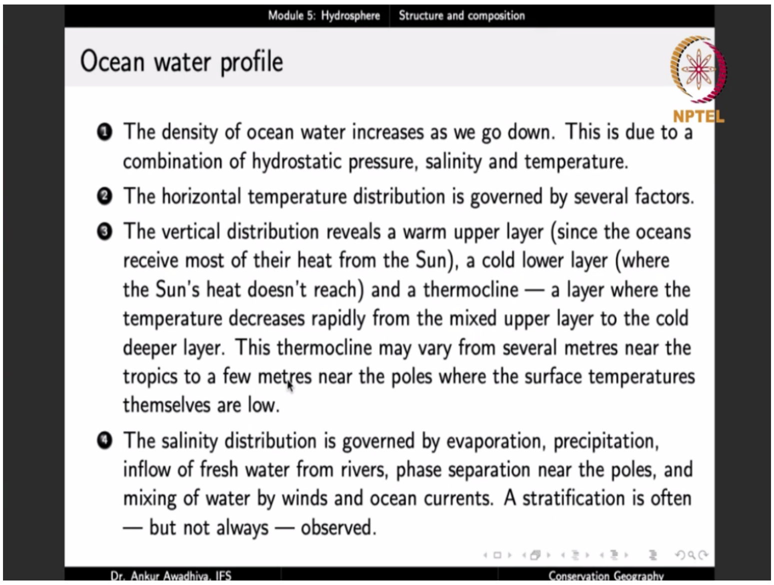

So, if we plot the thermocline this is how it will look like on the x axis here we have the temperature. So, the top layer is at around 13 degrees Celsius, the bottom layer is around 4 degrees Celsius and this is a thermocline.

Then we have the salinity distribution, the salinity distribution is governed by evaporation, precipitation, inflow of fresh water from rivers, phase separation near the poles and mixing of water by events and ocean currents. So, there are a number of factors that govern the salinity. If you have evaporation, then water is removed as water vapor and the salts remain increasing the salinity.

If there is precipitation or rainfall over the seas, then the inflow of the freshwater from in the form of rains will reduce the salinity. If there is an inflow of fresh water from the rivers, that again will reduce the solidity.

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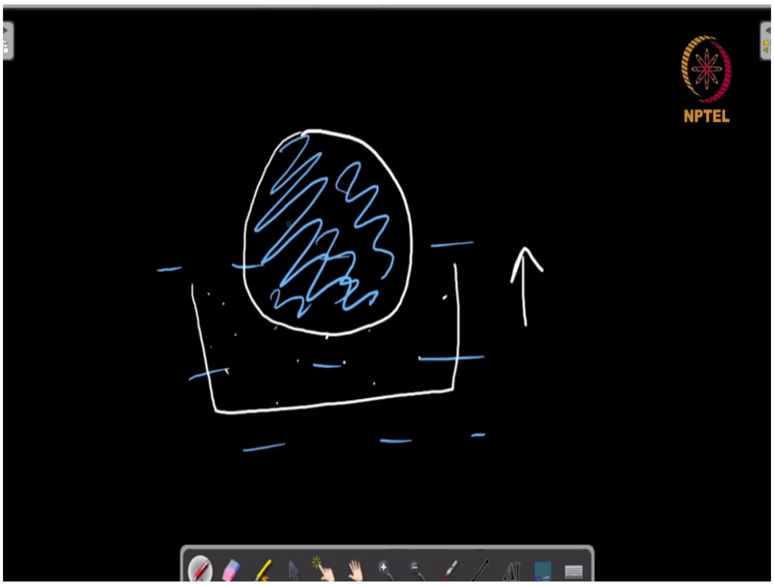

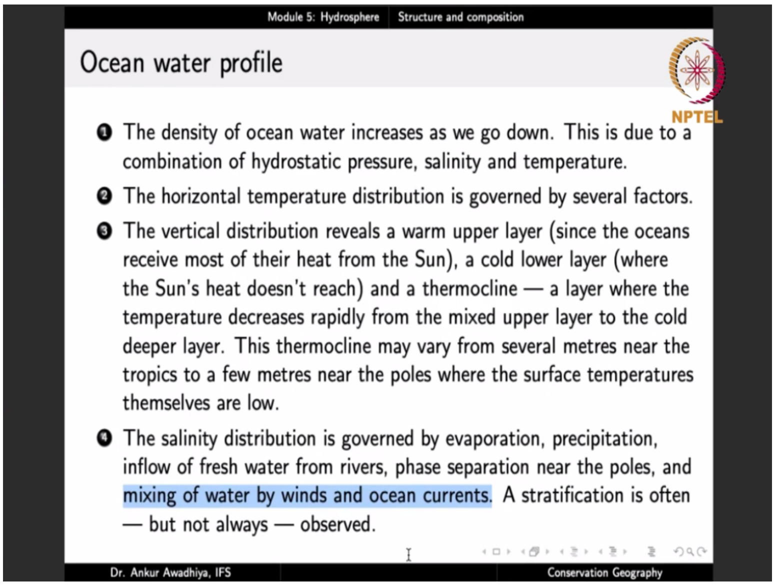

If there is a phase separation, especially near the poles, so in the case of phase separation, when we talk about water, that is having the salts when this water freezes, then the ice that gets formed, it will not be having any salt. So, this ice will be all made out of water. So, what happens to the salts, the salts are moved out. So, only the pure water gets into the ice and the salts are left behind because of which the concentration of salts in the remaining water will go up.

Now, this process is known as a phase separation, because the water phase is separating itself from the salt phase and because of this phase separation, we find that near the poles, the water is extremely saline and this saline water is also extremely dense it is extremely cold and so it moves down towards the ocean bottoms, to jumpstart a conveyor belt circulation of water in the oceans, we will have a look at it in a later lecture.

And mixing of water by winds and ocean currents. So, if there is a mixing of waters that will also change the salinity. A stratification is often observed but it is not always observed. So, you can have a stratification in which case the top layer has a different salinity, but it is not always necessary.

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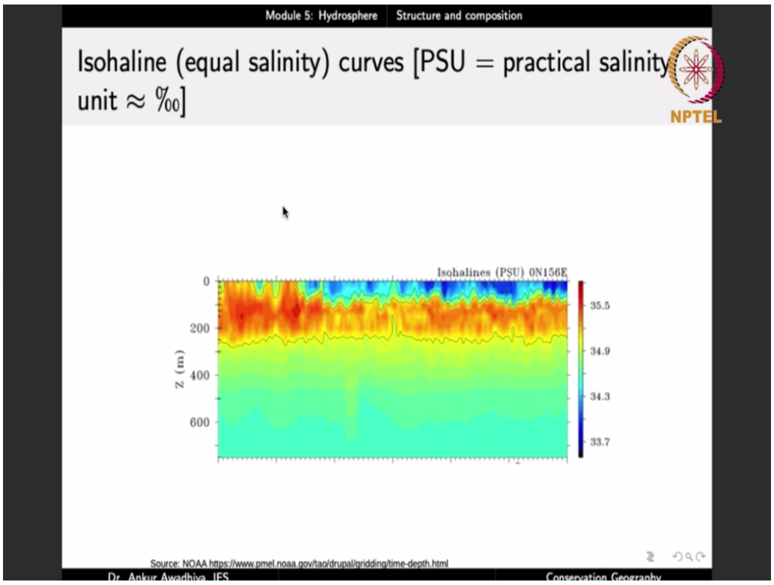

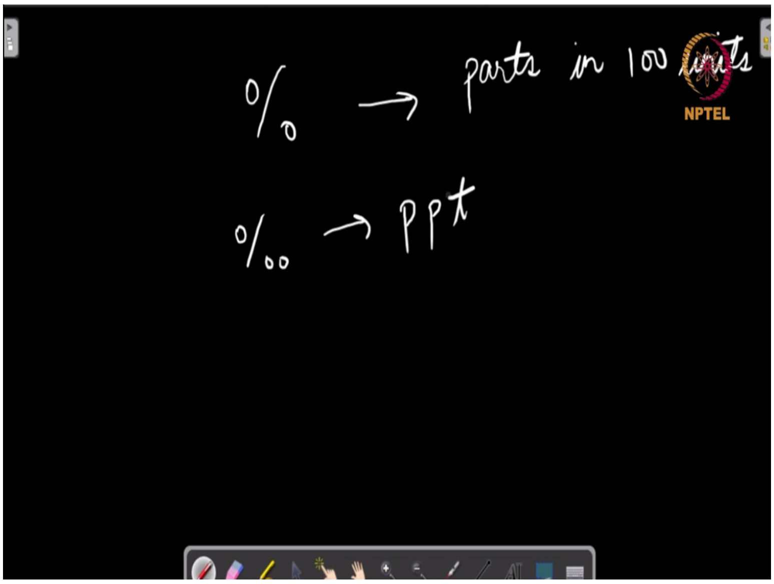

So, this is the Isohaline curves which is the equal salinity curves in the units of PSU, so, PSU is Practical Salinity Unit, which is very close to per mill. No per mill, it is very similar to the concept of percent. So, when we say percent, we mean how many parts in 100 units of something, when we say per mill, it is how many parts per 1000 units of something. So, for 1000 units of water, what is the amount of salt? So, that is what this PSU is referring to.

Now, in this curve, we can observe that below you have a salinity that is close to around 34.6. Then here in the top you have a higher salinity, but then in the layer above this, you have a lower salinity. So, essentially the salinity is a property that is very difficult to characterize in terms of general rules. So, for instance, in the case of temperature, we can always say that the top layer will be having a higher temperature, and the temperature will go down as we move down.

But we cannot say a very similar thing in the case of salinity, because it is governed by a number of factors that keep on changing. So, it is possible that the top layer has a high salinity, but then you have a rainfall and so the salinity drops. So, because of that we cannot make a general rule.

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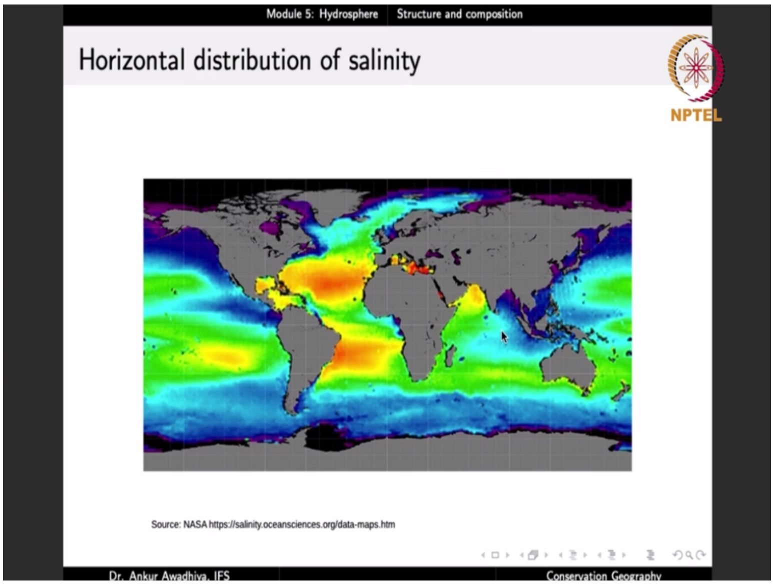

If you look at the horizontal distribution of salinity, this is what it looks like. So, there are certain areas that have a higher salinity, there are certain areas that have a lower salinity. And typically near the poles you have a very high salinity because of the phase separation. And near the equator, you have a lower salinity, mostly because you have a lot of rainfall that occurs in this area.

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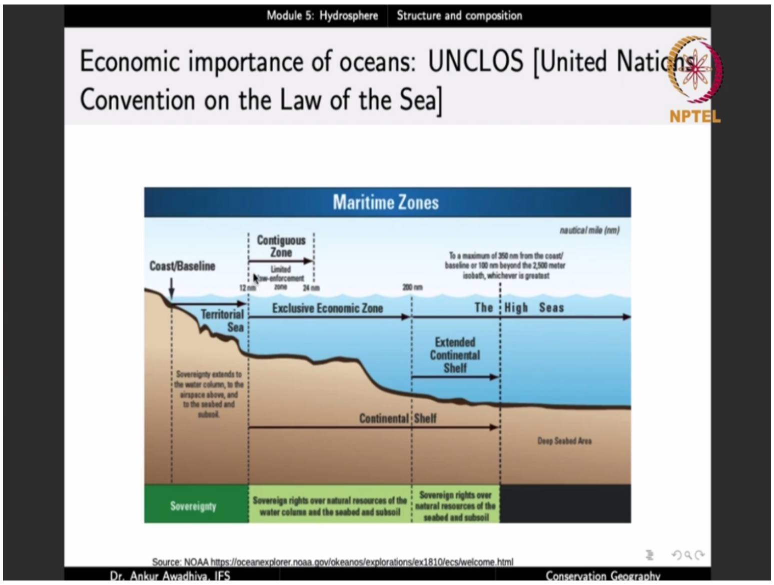

Now, in this context, we can also talk about the Economic importance of the oceans. Now, oceans are very important from the point of view of economics, because when we talk about a number of resources, when we talk about fishes, the oceans have lots of fishes. So, catching of these fishes sustains a very large fishing industry. There are also other animals that live in the oceans, they can also be harvested.

The ocean bottoms have nodules of metals such as manganese, they can be mined from there, the ocean is also a big source of salts as well as water. So, a lot of water can also be made use of say, by putting it through a desalination process. So it can be converted into fresh water to be used for drinking or to be used for agriculture. Similarly, when we talk about the waves, or the winds that are blowing in this area, then they can be used as renewable sources of energy.

When we talk about the continental shelves, we saw that there is a lot of deposition of sediments in those areas, a lot of deposition of fossils, which over time have been converted into fossil fuels, especially petroleum and natural gas. So these can be extracted from these areas. So the oceans have a very big economic importance. Areas that are near the shores that become often become port cities because they have an important place in global trade.

You have a lot of tourists that come to sea beaches. So there is a huge amount of economic activity that goes on near the oceans. Now, who owns the oceans? This question was resolved by the UN Convention on the Law of the Sea. Now, this convention sees that, till a distance of 12 nautical miles will say that this is a territorial sea. And in the territorial sea, there is a complete sovereignty of the nation that is here.

And this sovereignty extends to the water column to the airspace above and to the seabed and subsoil. So all of this belongs to the country that is here. Then we have a contiguous zone from 12 nautical miles to 24 nautical miles, where we have a limited law enforcement activity of this nation.

Then up to 200 nautical miles, we have an exclusive economic zone or the EEZ where the nation has sovereign rights over natural resources of the water column and the seabed and the subsoil. So all of this belongs to the nation. But the, the resources here, they do not belong to this nation because there is no sovereignty. This is just an exclusive economic zone.

Then we have the extended continental shelf, followed by the high seas. Now, the nations maintain sovereign rights over natural resources in the seabed and the sub soil in the extended continental shelf as well. So extended continental shelf is defined as a maximum of 315 nautical miles from the cost or baseline or 100 nautical miles beyond the 2500 meter isobath whichever is greatest. What is 2500 meter isobath? It is the point at which the depth of water is 2500 meters.

So, if you take this point, if you plot it, we can take 100 miles to the outside. And this is the, this is defined as the extended continental shelf. So up to this point, you have a sovereign right of this nation, beyond, you have the high seas. And in this case, you do not have any sovereign rights and all the nations have equal rights to exploit the resources in these areas. Now, such an arrangement was made to resolve the disputes between different nations regarding who owns these resources.

There are a number of problems with such arrangements such as what happens when the coastlines are in the form of a curve. So, in that case, multiple nations can hold sovereign rights over the same resources. But there is also another point that becomes very important from the point of view of conservation. Suppose, the nation that holds sovereign rights, if that nation is doing an activity, that is also polluting the seas.

Then in that case, because the seas and oceans are all one single connected body, then the impacts will be felt by the other areas as well. And we have observed examples, such as in the cases where the, the oil rigs in the continental shelves have leaked oils, or they have exploded as in the case of the Deepwater Horizon accident. Now, in that case, the petroleum that gets released, it floats and it reaches to very far off areas.

So while the countries have a sovereign right over these areas, it is important that any activity that is done in these areas is done with a lot of prudence and with a lot of concern for the environment. Because if something goes wrong, the impacts will be felt over a very large area. Similarly, when we talk about these exclusive economic rights, if the nation does an overfishing, or an over exploitation of resources, then it is possible that the biodiversity will get lost, or it is even possible that certain species will be pushed towards extinction.

So while the oceans have an economic role, it is important that we do not look at them just from the point of view of economics. You should also have a look at them from the point of view of biodiversity, because biodiversity is something that belongs to all of us. And it is everybody's responsibility to protect, preserve and conserve this biodiversity. So if something is going wrong in your area, it is your duty to point it out, and try to stop it. So that is all for today. Thank you for your attention. Jai Hind!