Advanced Aquaculture Technology
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Lecture 56
Topic - Impact of Climate Change on Aquaculture

Hello everyone, welcome to the first lecture of the module 12 Environmental consideration of aquaculture. So, in this particular lecture, I will be discussing about the impact of climate change on aquaculture and it will be followed up by the next lecture video as well. My name is Professor Gourav Dhar Bhowmick, I am from the Agricultural and Food Department of IIT Kharagpur.

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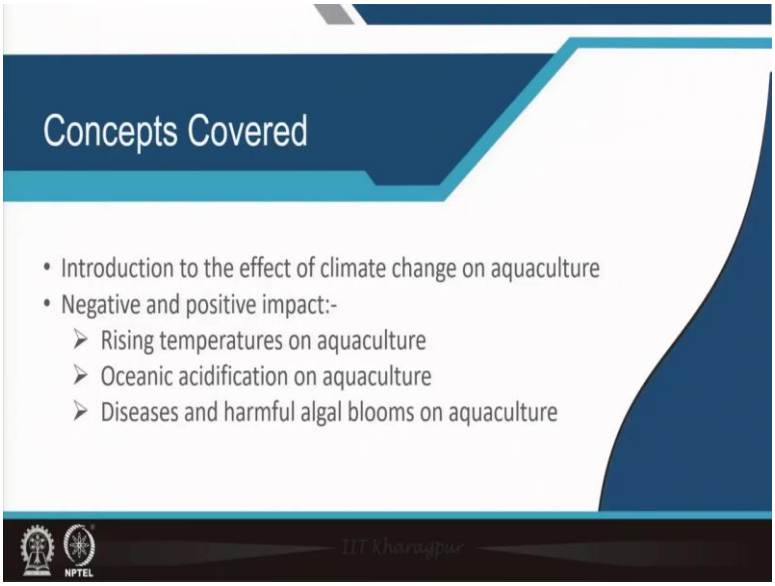

In this particular lecture video, I will be covering mainly the introduction to the effect of climate change on aquaculture, different negative or and the positive effects of or the impacts of rising temperature on aquaculture, oceanic acidification of on aquaculture and diseases and harmful algal blooms on aquaculture. Other than these three different topics, I will discuss about more on different more on you know, more like some other climate change criteria, which has some drastically effect on the aquaculture, but it will be done on the following lecture only okay.

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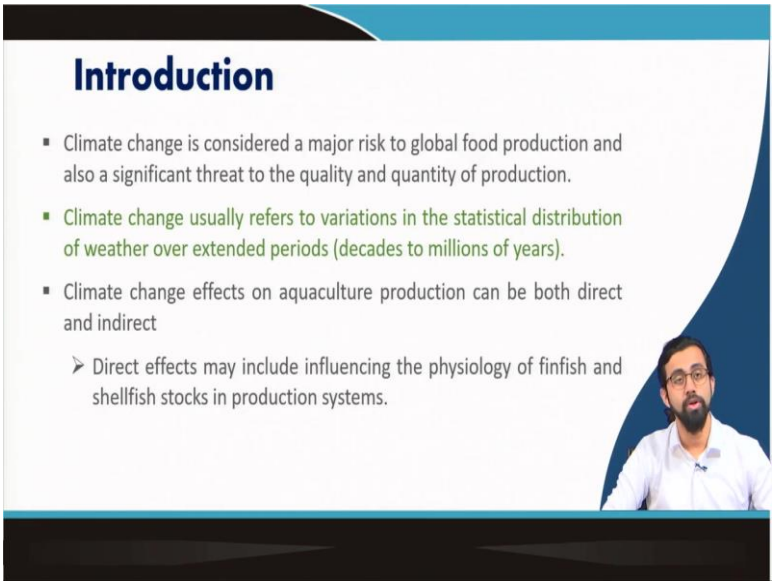

So, in order to start with, you know that the climate change is not something new that we are discussing today right. So, it is there and we are discussing now it is in a very you know, how to say like it is already there, we know it from like our school days that the climate change is happening and it is because of mainly climate change is something that it happens naturally also, but we are actually kind of you know, accelerating it by different anthropogenic activities.

Because we were trying to do something which is against the nature, we are trying to do something which is you know not supposed to be done by naturally in this timeframe. But we are doing it when accelerating this process and somehow, we some sometimes will decelerate some process as well.

So, both of the cases, we actually make a drastic impact on the environment and that because of that there is a chance of changes in the climate. So, this is actually one of the major risks, considering the global food production, and also it has a very significant threat to the quality and the quantity of the production of agricultural products and aquaculture products.

In general, when we talk about the climate change, it does, there is a difference between climate and weather right you know it right?. It like from our basic geographical knowledge, geography knowledge, that the climate change, it is actually a statistical distribution of weather over a particular period of time over an extended period of time okay, it can be decades to millions of years. So, that is what we call climate change okay.

So, this climate change, it affects the aquaculture in both direct as well as indirect ways okay, what will be the direct effect and what is actually the direct effects that is still actually in the aquaculture sector is facing nowadays, whether it be freshwater aquaculture, whether it be marine aquaculture and all. Is the physiology of finfish and the shellfish stocks are getting influenced because of these changes in the climate condition and all.

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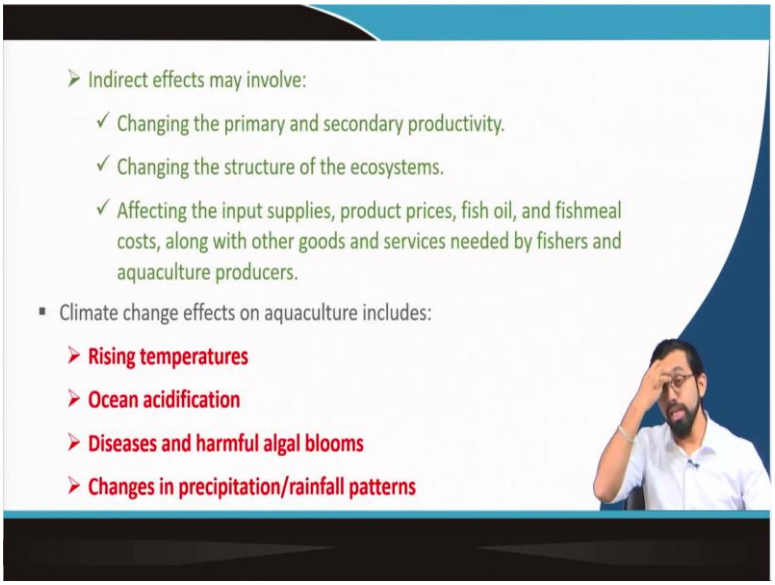

It also drastically affects its production systems and which actually implies that your aquaculture production will be hampered, if there is it is in continuous effect of the climate change and all okay.

What are the different indirect effects they are associated with aquaculture? First and the changing in the primary and the secondary productivity. What do I mean by the primary and the secondary productivity? That in the food chain when we have this food pyramid in the bottom level, we have certain, animal certain species of animal or plant whatever it is. Then in the second there will be some second tropic there will be like some other species which normally sustained by the help of the species which is there in the bottom most. Likewise, it will go and go on go for right?.

So, this change in the climatic situation can drastically affect this bottom most layer and the top like second bottom or like say like third bottommost layer okay. So, these layers are like kind of a building block for all the other for the food chain. And once these basic building blocks are missing, the food chain will like, the foundation of this food chain will collapse and it will drastically affect the whole ecosystem isn't?

So, because of that it is like a kind of an indirect affect. So, by means of this aquaculture will also be affected because they will not get enough food for the species to survive, because for them the food is this primary and the secondary produce right.

So, once they are missing the aquaculture growth will be drastically sublime. So, this is the reason and also it can change the overall structure of the ecosystem as I already discussed and it can also affect the input supplies, the product prices, fish oil and fish meal because if the fish oil and fish meal is normally, we collected from the capture fisheries in general. Still now, it is the like one of the major in a way of getting fish meal and fish oil is the capture fisheries. There is small fishes like you know anchovies and all.

So, this is the one that once because of the climatic changes which situation because of this drastic change in the environmental situation and all. The capture fisheries will be affected and once the capture fisheries is affected, they will get the less catch definitely that will affect the whole aquaculture system as well okay, you understand how they are, related to each other. Not only that, it also drastically affects the other goods and services needed by the fisherman and also aquaculture producers and all okay.

In general, the climate change effects on the aquaculture it includes the rising in temperature, ocean acidification, disease and the harmful algal blooms, changes in the precipitation or say like rainfall pattern.

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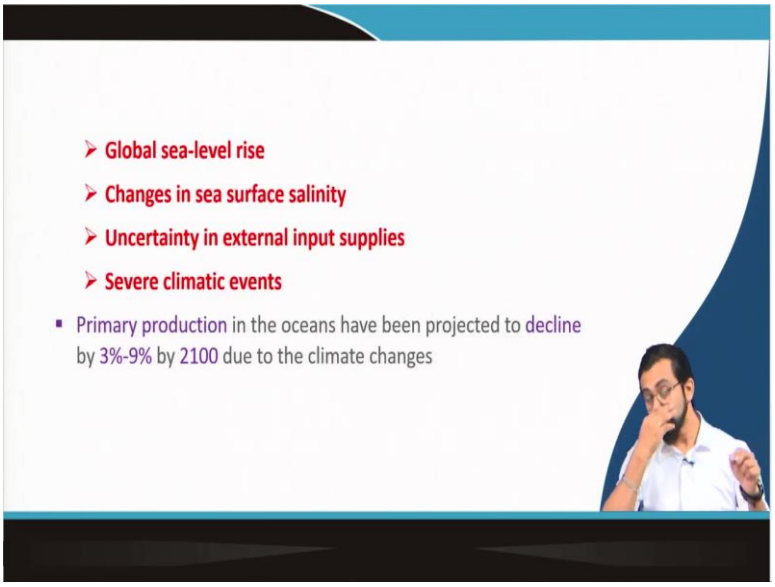

Global sea level rise because of this greenhouse effect and all, changes in the sea surface salinity, uncertainty in the external input supply, like agriculture and all and also severe climatic events. All these topics are very much influenced because of very much it can drastically influence the aquaculture.

So, we will be discussing about the first three today okay. The rising temperature ocean acidification and the diseases and harmful algal blooms, all the follow up effects will be discussed in the coming lecture video okay.

Primary production of the ocean have been projected to decline by 3 to 9 percent is by 2100 due to this climate changes. Can you imagine this just realize the fact that because population explosion is happening right?. So, in any way the amount of people the amount of supply is keep on amount of, demand is keep on increasing.

But the supply, if by the end of this century, if it will be declined by 3 to 9 percent as of this from the oceanic primary production from the ocean. It will have a very drastic influence in the food chain, there is a chance of drastic effect in the whole ecosystem because of this reason. How they there is a chance like there will be high famine and, the high rise in the food and all food prices will rise like anything, it is like even it is actually happening. It is do not worry about it is not something far future thing that we are discussing about.

It is actually happening all over the world right now, the food prices are keep on increasing like anything unless until we try to think about the alternates. If you remember we discussed couple of very fine alternative methods of aquaculture and aquaculture based agriculture in our lecture in this in different lecture modules in this series of lecture.

So, if you remember all those methods like aquaponics like we discuss a particular hydroponics and all, we discuss about the seaweed, we discuss about the pearl crabs. So, the sea ranching, aqua ranching and all these processes are having you know very high potential to be the future of the human food production and all.

Because unless until we think about the alternatives or unless and until we think about how to replenish the environment that we already destroy okay like the in case of in this particular case this because of the climate change that is happening due to the anthropogenic activity and because of that this global change and all those things.

Unless other unless and until we change, we change our way of leading life unless we change the reduce the carbon footprint of our system like what the whether it be your municipality, whether it be your industry, whether it be your aquaculture farm or whether it be livestock farm or agriculture, whatever. Each and every individual things have their own carbon footprint.

They have their carbon demand and all which has to be reduced. Think about forget about reducing now think about the how to do it, Carbon like you know then like do it negative, like rather than your being you like I would say in this particular sense you can even say your carbon positive means. We know some countries are there which are actually fighting like anything in this sense. So, your moto will be you will be producing more amount of sustainable gaseous sustainable like say like more amount of oxygen.

And I say like, if you have a proper reference suppose like carbon dioxide if you can consume the carbon dioxide is much higher than the production of carbon dioxide that is what our goal is okay. Like Bhutan, Bhutan is I think one of the first country in the world which produces which consume more amount of carbon dioxide from the atmosphere, then the amount of carbon dioxide that they are generating from their country, we have to take it as you know as a kind of example or something, we have to idolize this kind of behavior all over the world.

How we can reduce this kind of drastic climatic effect by changing our human behavior and changes in some production level and all these things anyway. So, that is what we need to do as soon as possible because the clock is ticking and 2100 is like even a very far estimate. It can be happened before that also in you or your future generation will be drastically hampered by that okay.

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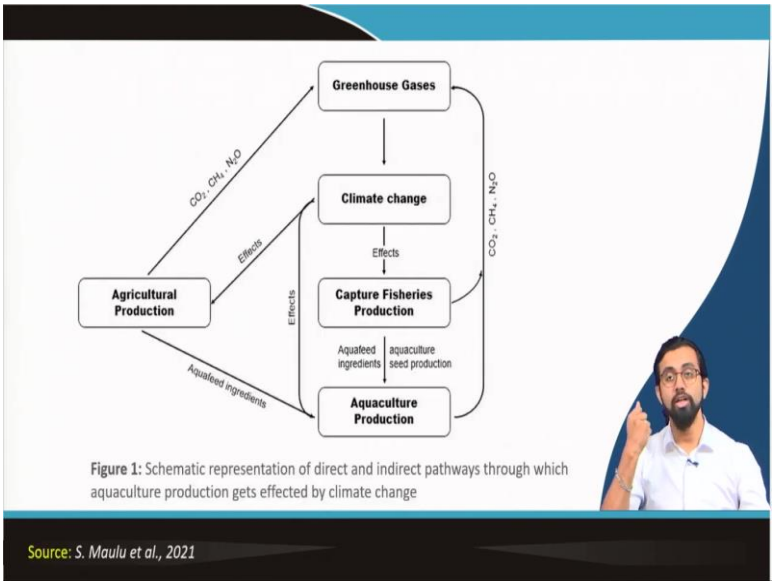

So, in general, if you see this representation, you will get an idea about, how this all these systems are actually interrelated aquaculture, agriculture, climate changes and all. In the aqua culture production, it produces carbon dioxide, methane, nitrogen dioxide and all, nitrous oxide and all.

And this nitrogen base oxide is this greenhouse gases like this methane and carbon dioxide, it actually increases the greenhouse gas with the amount of greenhouse gases in the atmosphere. It can definitely changes the climate in the long run. And it definitely affects the agriculture production in the whole.

So, it is like a circular thing like once you are not maintaining the temperature, you are not maintaining a sustainable production method, you are not maintaining this sustainability, definitely it will increase the production of greenhouse gases which will which will affect the climate change, which will affect the whole your agriculture production as well.

It will also affect the capture fisheries and because of the effect on the capture fisheries, it will reduce the aquafeed ingredients which is like fish meal or say like fish oil. So, if the fish meal and fish oil is reduced, the whole aquaculture production will also be hampered. So, once it is hampered, it will also you know started reducing because of that there is a reduction in the amount of food availability and all. All together whole system will be drastically affected like the agriculture production, aquaculture production will be reduced like anything because of these changes in the climate and because of our unsustainable farming practices and all.

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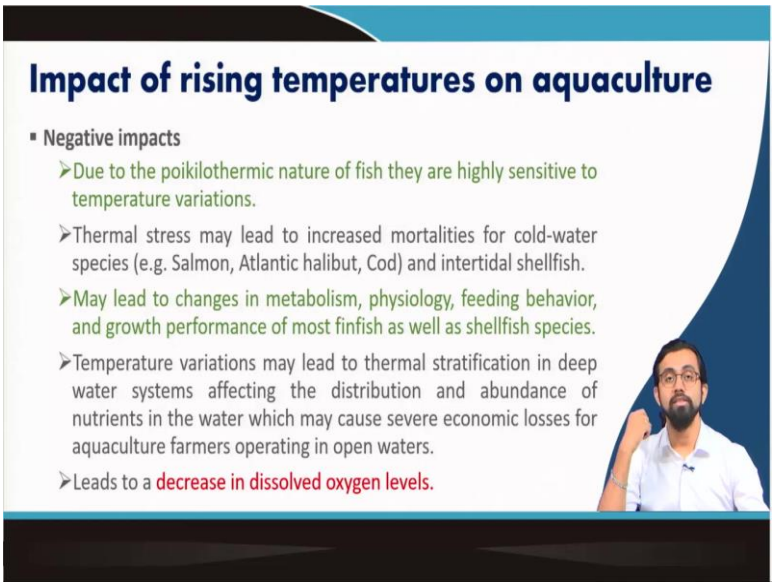

I will discuss about these three points as I discussed as I told you, like the what are there impacts negative and the positive impact on aquaculture. So, first to start with, let us discuss about the rising in temperature. I hope I do not have to go through much more in details because I am 100 percent sure you all know the fact that how this rising temperature can affect the aquaculture. Especially the reason like why the rising the temperature is happening because of the climate change.

Anyway, so let us discuss about the negative impact first, you know the fish is normally they are Poikilothermic in nature. What do I mean by the Poikilothermic? That means, they do not have the capacity to control their own body temperature, their body temperature is completely relied on the external temperature or the external environment okay. So, definitely they do not have the accessibility they do not have this capacity to control their own body regulation this heat regulation system and all. Because of that, they are highly sensitive in even minor temperature variations and all okay.

This thermal stress can lead to increased mortality for the cold-water fishes because like Salmon, Atlantic halibut and this Cod and all and also the intertidal shellfish. They normally cannot sustain higher temperature, they normally prefer to have it in a temperate region and stay in the temperate region with much less temperature than like in general the much less temperature around say like on an average 8 to 17, 18 degrees Celsius or something like that.

If it goes above that it will be in a stress condition which will lead to different kinds of reduction in the reproduction level reduction in the overall the biomass production and all of those things. Overall production will be hampered, it can lead to the change in the metabolism, the physiology, the feeding behavior, the growth performance of most finfish as well as the shellfish species.

This temperature variation also led to the thermal stratification in this deep-water system and which affects the distribution and the abundance of nutrients in the water. And what will happen if the distribution and the abundance of nutrient in the different water level is different? It will change it reduce it can affect severely the aquaculture farmers who is operating on the open water like what do I mean with open water? Say like they go to the open sea, in the open sea we are having this particular type of pen or cage culture or like simply we go to go and do the capture fisheries and all.

Because of the change in the temperature variations, this nutrient abundance will also vary it will not be available in the upper stratum. So, it will go to second or third stratum of the water and because of that the species which normally dwell there their amount will be reduced and which will definitely affect the aquaculture farmers okay. It can also decrease the dissolved oxygen level.

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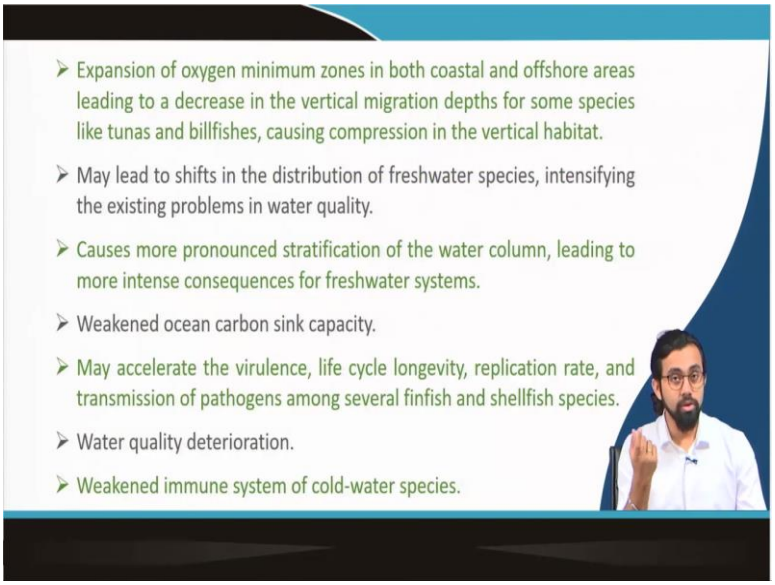

Like if you increase the temperature DO will decrease, because if you increase the temperature all the dissolved oxygen will get vaporized. So, we will get in contact with bubble make this bubble form and it will go into go in contact with the atmosphere and all.

So, it is I mean like see, in general that if you increase the temperature the gas diffusivity will decrease right. So, it is like the same if you increase the temperature differently the oxygen level will reduce which will affect I do not have to say it right which will how it can affect the all the living system present in your aquatic system and all okay.

Also, the expansion of the oxygen minimum zone, say, in both coastal and offshore areas, it can decrease the vertical migration depth for some species like tuna and billfishes, they normally go for you know, they normally have these vertical habitat systems they go up turns, up in the surface and then they go back again to have some food and then they are going to for phytoplankton sand and they go back again. So, just to giving some examples, so, this vertical expansion of their this habitat is getting compressed because of the changes in the oxygen minimum zones.

It will lead to the shift of the distribution of freshwater fishes like an intensifying the existing problems of water quality, it can cause the pronounced stratification in the water column and leading to more intense consequences in the freshwater systems. It can weaken the ocean carbon sink capacity, what do I mean by the weakened ocean carbon sink capacity? That though we talk about the if you plant more, like do the plantation and all just like in every fifth June we organize this World Environmental Day and, on that day, only, we just go on plant a lot of terrestrial plants and all.

But do not forget this fact, that terrestrial plant is okay, you just you should definitely do that, because that is in your hand, but you do not have to it is better to remember that most of the carbon dioxide that is getting consumed from the world is done by the oceans. And the percentage is very high and oceanic these plants are one of the major reasons of carbon sink for the world like you know they know this.

They can consume the maximum amount of carbon dioxide present in the atmosphere and it can make it to it can somehow you know close it the closest that is why we call it carbon sink. Means they go and they collect there they convert it into some other molecular form and because of that, we can reduce the overall carbon dioxide concentration in the atmosphere.

This carbon sink capability of the ocean gets drastically hampered because of these changes in the temperature and all. It may accelerate the virulence lifecycle longevity replication rate and also transmission of pathogens among the several finfish and shelfish species.

Water quality is definitely can get deteriorated because of less DO, definitely the other type of anaerobes and anoxic micro system can grow and they can this type of microorganism can easily replace the beneficial ones. And also, it can weaken the cold-water species eco immune systems and all.

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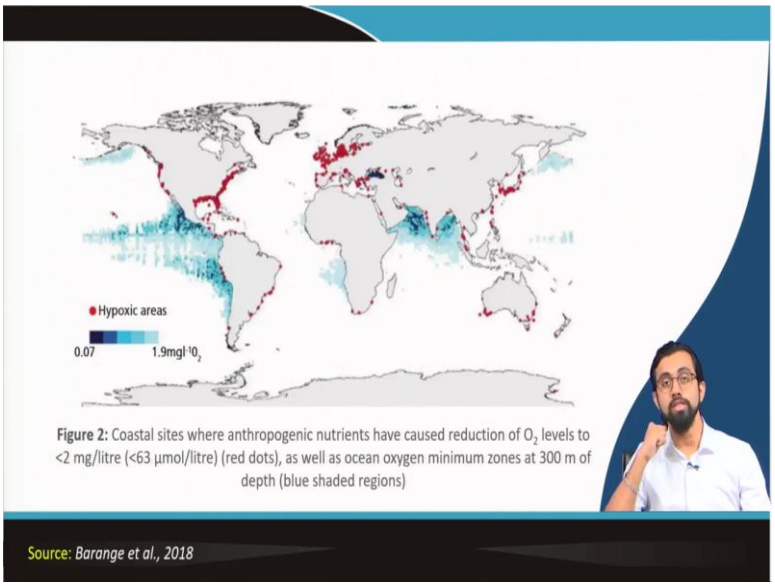

If you see this, this particular figure these are the coastal sites. It shows see the red dots is actually showing the reduction in the oxygen level to less than two milligram per liter, which is like around two ppm less than two ppm right?.

It is because of the anthropogenic nutrient and this anthropogenic activity because of this anthropogenic activity. Anthropogenic means like human activity, because of this, the reduction of oxygen level happens in these red dots and these blue dots if you see they are the oxygen minimum zones had 300 meter of the depth. Within 300 meter of the depth there is like oxygen minimum zone, which is like hypoxic area, this see it is the oxygen concentration is very low see 0.07 to this, if you see this hypoxic area is the hypoxic areas are red dots and these blue dots that deep blue is representing 0.07 milligram per liter of oxygen only.

If you go light blue is actually showing it is almost okay up to 1.9 milligram per liter, but still, it is really less it is really, really less we have to really think about it. Because in those regions the sea a different aquatic species will find it is hard to survive in these regions, these hypoxic areas obviously, these red ones and these blue ones also.

So, in this play, because of these changes in the temperature, this changes in the oxygen level is happening in these regions and which will which is actually drastically affecting the overall

capture fisheries and all. And that is why people are more prone to go for this aquaculture and all. Which is one way good you should go for aquaculture practices and scientific way if you do it can be done in sustainable way.

But in Capture fisheries definitely you should it is no way it can be better no way it is better or it has positive impact on environment okay. Capture fisheries is simply to my experience, if you ask me my expert opinion, you should not go for capture fisheries is just no, let them thrive their own ecosystem do not go and disturb it. So, anyway, so, that is how this temperature is affecting.

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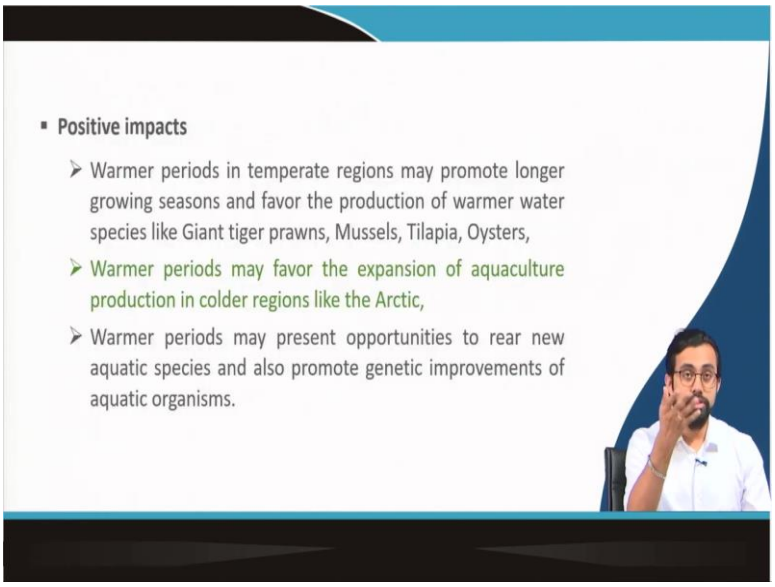

So, every side has some other part every coin has this other part is the same way other side. So, like the positive impact the temperature difference, the rising temperature can also be beneficial in some sense, what are the ways that I can say it is beneficial? Some warmer water species like giant water prawn, mussels, tilapia, oysters, they started growing they can be grown in the temperate regions nowadays.

Because temperate regions, they were not supposed to be like this kind of species were previously we were not be able to culture them in these temperate regions, but now, because of the warmer climate, people start doing it because for them also, there is like ample opportunity now to grow this different aquatic species.

They are this warmer periods it favored the expansion of aquaculture production in the colder regions like in the Arctic and temperate and this warmer periodic may present the opportunity

to rear new aquatic species and also promote the genetic improvement in the aquatic organism in general.

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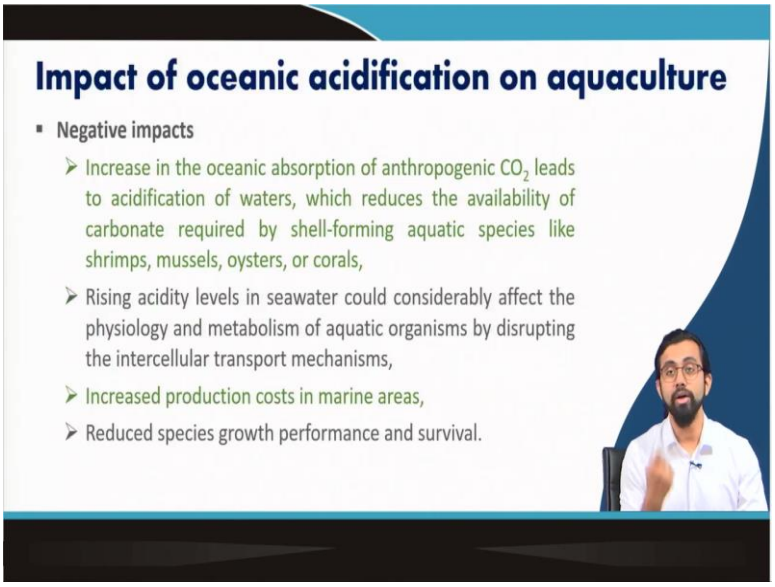

Second thing is oceanic acidification, what is the impact of oceanic acidification on aquaculture? What is the negative impact to start with? It increases the because of the anthropogenic oxygen carbon dioxide which normally we released to the atmosphere.

It increases the oceanic absorption level and which lead to the acidification of water and once this acidification happens it reduces the availability of carbonate for different shell forming aquatic species live shrimp, mussels, oysters, corals et cetera. Why? Because I will give you one very nice graphical representation in the next slide where you can get a more in in details idea about why it is happening okay.

What is the other impact like rising the acidity level in sea water could considerably affect the physiology and the metabolism of the aquatic organisms by disrupting their intercellular transport mechanism, it can increase the production costs definitely it can reduce the species growth performance or survival and how it happens?

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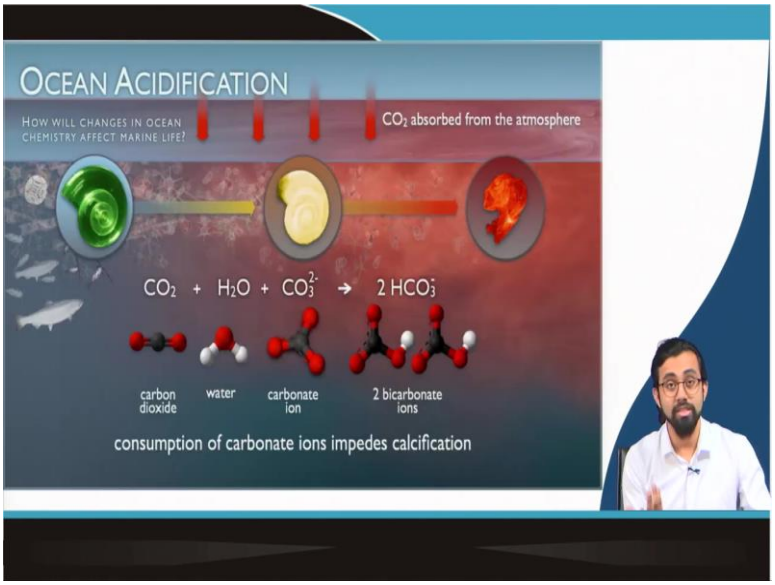

If you see in general for the green one that is like in one say like shellfish one is there. So, suppose, what happened with time the carbon dioxide because of the anthropogenic activity the carbon dioxide level is rising. Ocean is started trying to sink as much as try to absorb as much as carbon dioxide as possible. Because of this overconsumption, this carbon dioxide along with the presence of carbonate ion it produces the bicarbonate ions and all.

Because of this bicarbonate ions presence of this bicarbonate ions and because of this consumption of the carbonate ions, it impedes the calcification because of the less amount of calcification the all the shellfishes, they cannot form their outer layer or exoskeleton. Their exoskeleton is mainly made of this the process of exoskeleton, the process of making this exoskeleton of this aquatic species are called this calcification that is drastically hampered because of the presence of high amount of carbon dioxide, which actually cause the acidification to take place okay.

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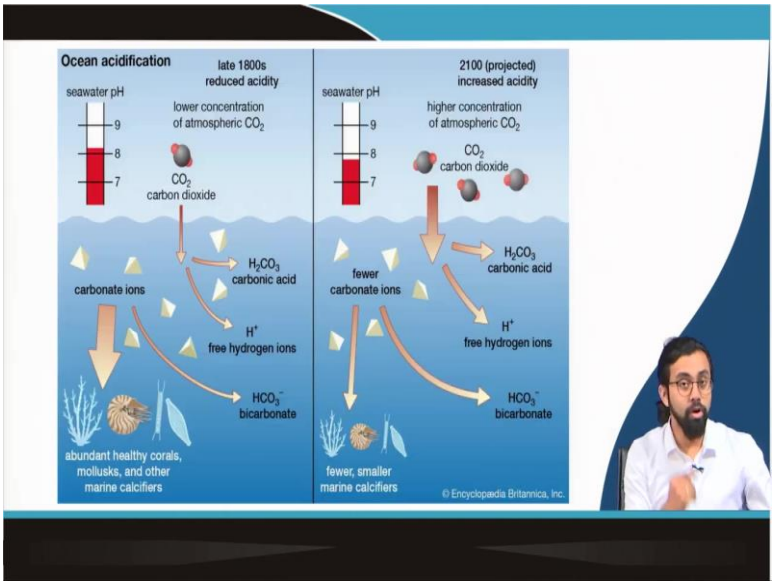

And what will happen if the acidification will take place? If you see this picture in late 1800 in the left side picture it shows what was there in the late 1800. At that time the Seawater pH was around 8 okay. But now in 2100 it is expected to be as low as 7 point at that time it was like around 8.1, 8.2 by the end of this century, it will be around 7.8, 7.75 something like that.

Though the number does not look so lucrative like right? it is like a just a small change in pH No, you do not know how much it can affect? It can just simply eradicate simply completely replenish all type of healthy you know, this marine calcifiers. Like especially corals, mollusk and all these things, they only very smaller marine calcifier can only be sustained.

So, because of that if you see the in the left side this carbon dioxide when it comes in contact with the sea it uses it produces this carbonic oxide carbonic acid free hydrogen ions and on. And also, when it comes on react with carbon ions it forms the bicarbonate but the production was not as high as nowadays it is there. If you see the you know width of the each and every arrow you can easily understand the amount of it like shows kind of intensity of that particular reaction that is happening.

Carbon dioxide level is rising it is coming in contact with the in the atmosphere see much higher rate and the whole and the discussion that we had like it will reduce the overall production of the overall classification process and it can drastically affect our sea water atmosphere I mean like the seawater ecosystem and all.

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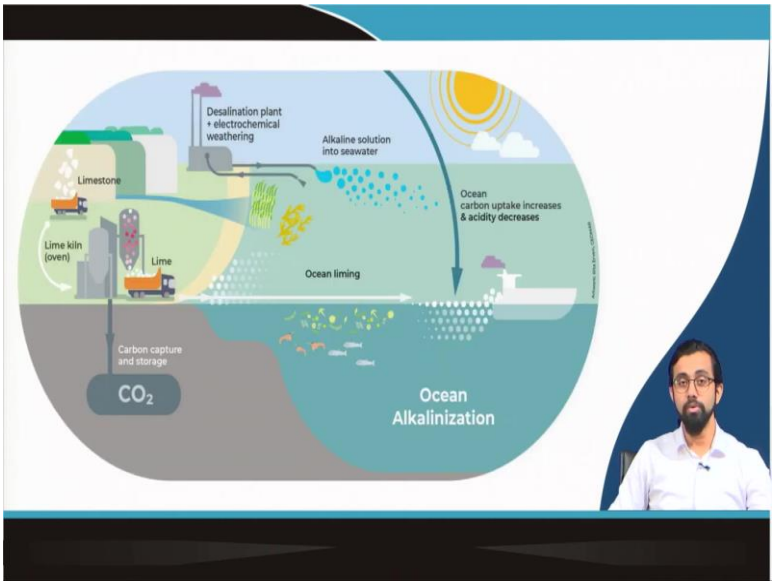

How to minimize this? You might be you might be very interested it is very interesting topic I really want you guys to be very, put your concentration on it like this is a very important fact that you need to know. How we can reduce or like, how we can improve the ocean alkalinity? We call it enhanced ocean alkalinity or enhanced ocean alkalinity and all this, this is a very standard process that you can find nowadays people are working on it okay. And if you start to start with, we produce limestone, we can get the lime or limestone. So, different kinds of this produce normally what people are doing, they are utilizing this lime or limestone and all.

These lime and all they simply dump it in the ocean region and all, what will happen? They react with this bicarbonate and all. And they because of this they once they react with this carbonate and bicarbonate and because of that they produce the final product like which is mainly the magnesium and the calcium compounds which can be drastic which can this product this final product is more stable in nature and they will go and settle down in the bottom. Because of that the ocean alkalinity can be increased, ocean acidification problem can be tackled. So, this is one way of doing that okay.

We normally do normally your motto is to provide the alkaline solution into the seawater, which will increase which will increase the first of all carbon dioxide uptake rate and also it reduces the acidity. Because the ones it will reduce the acid one the alkaline level will increase it will have much higher capacity to consume more and more carbon dioxide.

So, your target is to increase the alkalinity as much as you can in the oceanic region. For the ocean to consume more and more carbon dioxide, the more the carbon dioxide it will consume it pH will go down. And the more you keep on adding the alkaline solutions it will you can increase the pH much higher rate and that will. So, this way you can increase the overall carbon dioxide capture rate from this oceanic bodies and overall ocean alkalinization can be happened.

This is a very futuristic method and people are doing it nowadays in a very broad scale and it is expected that in future also that is one of the major way of tackling this you know ocean alkalinity problem and ocean acidity problem and all.

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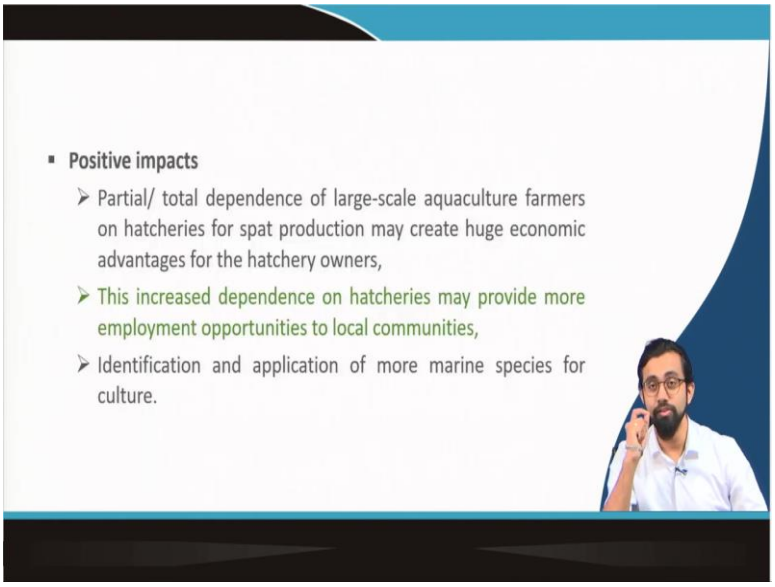

There are some positive effects as well I as I told you like because of this ocean acidity and all people started following the aquaculture in the hatcheries production in the hatchery or in the farm only. Because of that they started all the hatchery and all they are getting much higher economic benefit out of it. The increasing dependence on the hatcheries may provide more employment opportunity the local community. And also, the more intensification, identification and application of more marine species are possible for aquaculture purposes by the experts all over the world okay.

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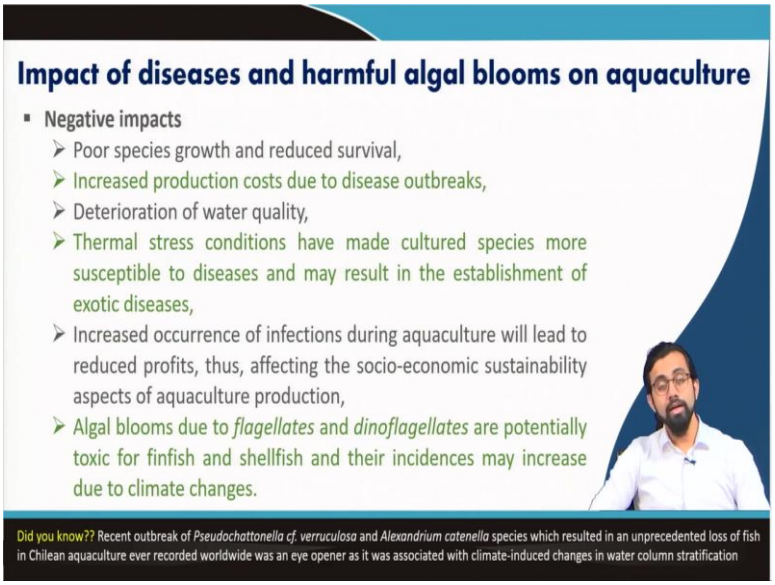

Last one, one that we will be discussing today about the impact of a disease and harmful algal blooms in aquaculture in general, what do I mean by this harmful algal bloom and all ? It is actually one of the major reasons of this is different kinds of cyanobacteria's actually okay. The cyanobacteria are the reason why this production of this different algal bloom this they and this cyanobacteria, they actually produce some kind of toxins, these toxins are very much harmful for the aquaculture produce and all okay.

So anyway, this in general, what are the negative effects of this disease and harmful algal blooms? It reduces the species growth and it can reduce the survival rate of the species, actual aquatic species that you are targeting, it increases the production cost because of the disease outbreak, deterioration of the water quality, definitely the eutrophication and all.

Thermal stress condition also have made culture species more susceptible to the disease and may cause in the establishment of the exotic diseases and all. It increases the occurrence of infections due during the aquaculture and which will lead to the reduced profit and also overall affecting the socio economical sustainability of the of your farm. Also, algal blooms because of these flagellates and the dinoflagellates are potentially toxic for finfish and shellfish and their incidences may increase due to the climate changes and all.

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In general, this Planktothrix species are the one of the dominant cyanobacteria and this is one type of auto tropic bacteria, which are causing this major algal bloom they are toxic that they are producing is very harmful. Other cyanobacteria like Microcystis or the *Anabaena* species are actually responsible for algal, this disease-causing algal bloom as well.

One of the major ways of replenishing this problem is like, like kind of broadcasting by providing sodium carbonate peroxyhydrate, which actually releases the hydrogen peroxide H2O2. And when it mixes with the water and this H2O2, it can kill the cyanobacteria and the same time it can break out break down the toxin that may be released, because of these organisms because of this species.

However, though, you can utilize this. Suppose your target is to kill the cyanobacteria and the toxins that they are releasing by introducing this particular chemical, because this chemical can produce H2O2 hydrogen peroxide, which has very high it is a very dangerous oxygen reactive species. What will happen? It will not only kill the cyanobacteria, but also it will cause some irritation in your aquatic species as well. So, you have to think about it either you have to take care of your aquatic species and treat your pond or lake first.

And then you put in like, put back all your aquatic species that is also one way of doing it or other way, you have to, somehow do it in a very small amount, so that it will not have a drastic effect on your aquatic species.

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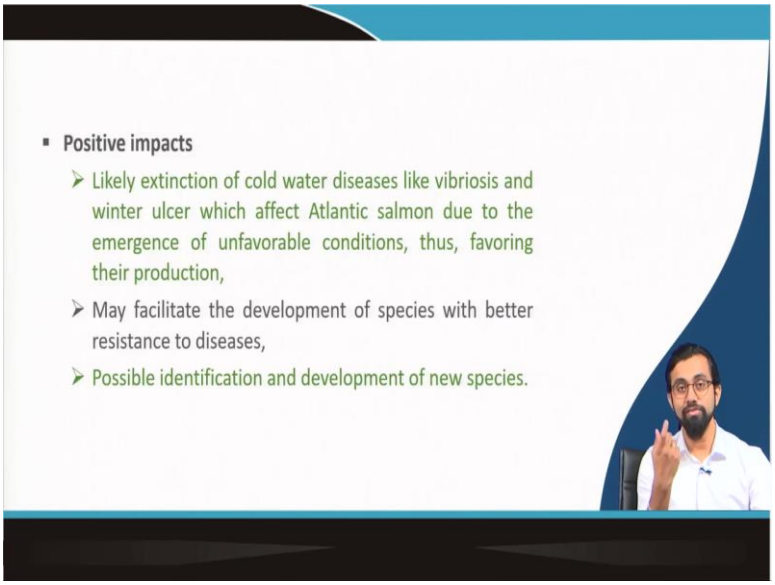

What are the positive impact? Likely, the extinction of this cold-water species diseases like vibriosis and winter ulcer which affects the Atlantic salmon due to the emergence of unfavorable conditions, thus, favoring their production at the end. Because the vibriosis or winter ulcers are like some of the disease, disease causing microorganisms which are like the microorganisms which are responsible for these diseases can also get killed because of the toxin that is released by cyanobacteria and all.

So, in one way it is helpful for the Atlantic salmon and all. It may facilitate the development of species with better resistance to the disease. And also, we can potentially identify and development of new species as possible for, it is like survival of the fittest. You have to find out the species which can survive the best in this harmful in this drastic environment situation and you can just throw it there and try to let it survive there.

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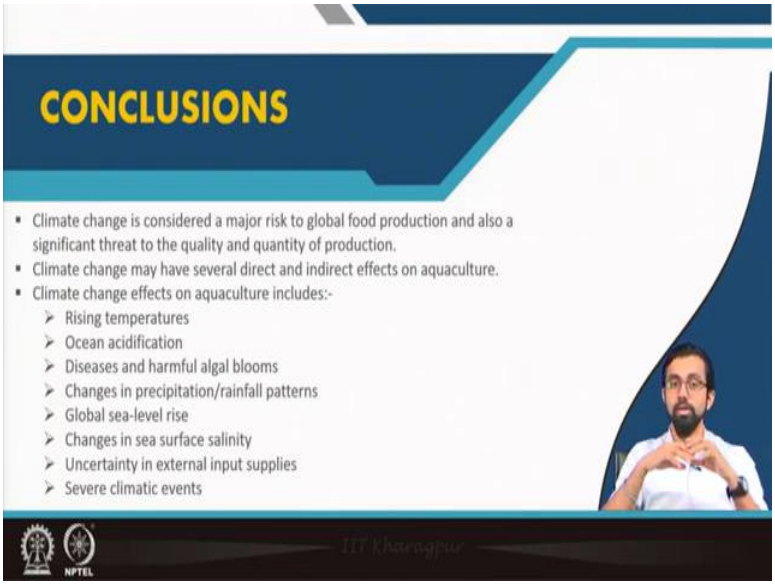

So, in conclusion, we know that climate change it has a major risk on the global food production and it can have a very significant threat on the quantity and the quality of your production. It has several direct and indirect effects. The major efforts we already discussed rising temperature, ocean acidification, diseases and harmful algal blooms. In the next coming lecture, I will be discussing about the changes in precipitation and rainfall pattern, global sea level rise, changes in sea surface salinity, uncertainty in external input supplies and the severe climatic events will be discussed in the coming lecture.

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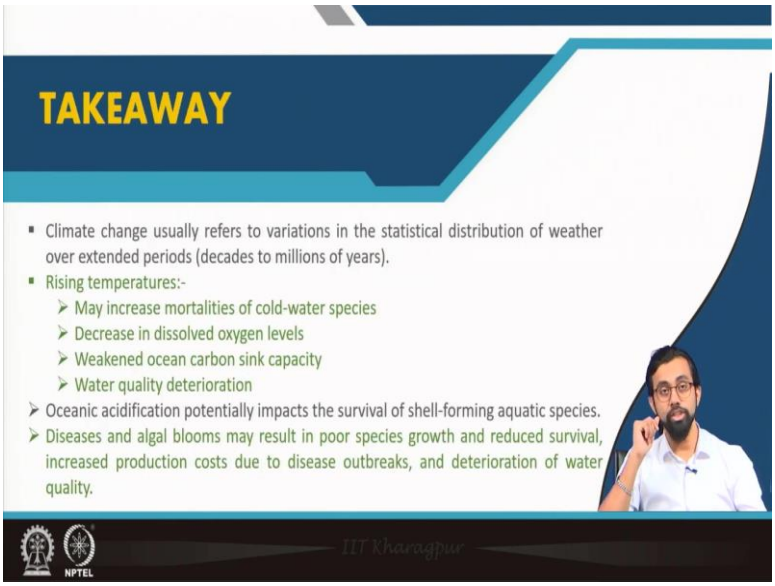

Overall takeaway, that climate change refers to the variation of the statistical distribution of weather over an extended period, it can be decades to like millions of years, rising temperature can affect the mortality of the cold-water species, it can decrease the DO content, DO level, it can weaken the ocean carbon sink capacity and will deteriorate the water quality.

It can also potentially the ocean acidification can potentially impact this shell forming aquatic species but it can be somehow you can rectify it by different enhanced oceanic alkalinity process by applying lime and all. The different diseases and algal bloom can result in very poor species growth and reduce the survival and increase the production cost. But that can also be tackled by application of different chemicals that also is discussed in this lecture material.

I hope you got to know some very interesting fact about the application the presence of climate change and how it can affect the aquaculture in general. I hope you will be more benefit and be more benefited in the coming lecture where you will be getting some more detailed idea about what are the different other factors, which like or the effects because of the climate change on the aquaculture. And I hope it will give you one very broad idea and it will definitely increase your knowledge on this particular matter and on this particular topic.

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These are the references that you can follow. And I hope you get to know some important and interesting facts in this lecture material. And we will discuss more about it in coming lecture. Till then, thank you so much.