Advanced Aquaculture Technology
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Lecture - 15
Seaweed Culture; Pearl Culture

Hello everyone. Welcome to the NPTEL online certification course on advanced aquaculture technology. I am Professor Gourav Dhar Bhowmick, from agricultural and food engineering department IIT Kharagpur. So, in this particular module, I will be discussing on the seaweed culture and the pearl culture.

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So the concepts that are will be covered is the global statistics on this particular scenario. Macroalgae or the seaweeds, its culture methods, oyster farming, and the pearl culture and the parameters affecting the pearl culture and their different culture methods.

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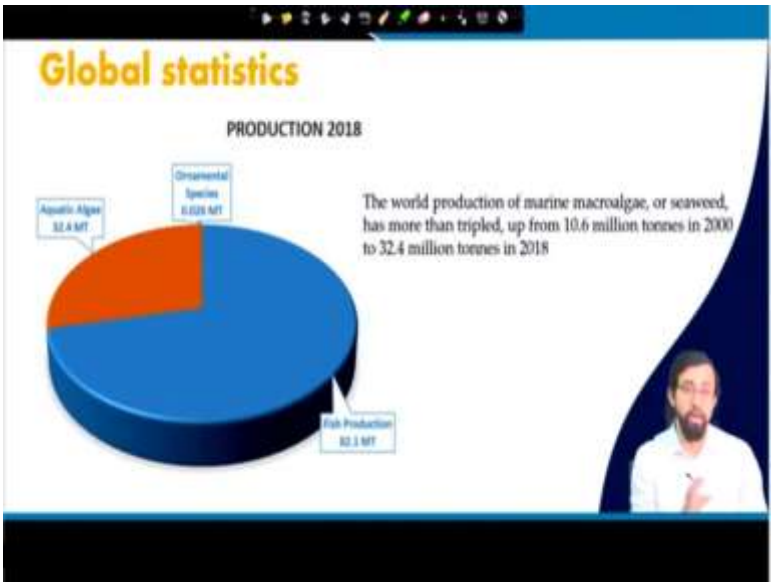

So, if you see the global statistics on the ornamental species, fish production and the aquatic algae, so the seaweed or the macroalgae production in the last, then like almost 20 years, it almost tripled from 2000. Data from 2000 it is like 10.6 million tones to 32.4 million tones on the in the year of 2018. And the projection rate for there is an according to the scientists and the researchers from all over the world for their, for them the the idea is by the end of 2030, it can go further, almost 5 times increment can be witnessed in this particular sector.

An ornamental species and fish production if we can see, if we can compare, if we see almost more than one third of the fish production, one third of the aquatic production. Almost one third of the aquatic production aquatic species production is now consumed now relates to the aquatic algae production, especially the macroalgae production.

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The macroalgae or the seaweed, it actually differs from the microalgae in terms of morphology and life cycles. And it used like different type of culture, methods and purposes are are there for the production of this macroalgae and all; and they are actually extremely different. It is normally used for the human consumption from fresh and also it can be in dried form. Fresh one I think like Japanese sushi and all it is very famous. If you go to the eastern part of Asia, this consumption of seaweed is very common.

Even in the US also in the western world also now people are started consuming seaweed in the different dishes; and it is considered as a very delicious and very rich in nutrient, in terms of like diet preparation and all. It is used for the medicinal purposes, it is used for the soil conditioner and the fertilizers I have already discussed in details in last lecture. It used for the gelling the hydrocolloid productions and all. So, what are these hydrocolloids? This agar, alginate et-cetera. So, which are actually now being used for this, agar can be used from the red and this alginate can be used from, can be found, can be easily collected or recovered from the brown algae.

So, these seaweeds which are benthic in nature, normally grow in the solid substrate like rock and all. But, however, most of the species now in we can easily farm it, in a freely floating or suspended in the water column in the liner linings.

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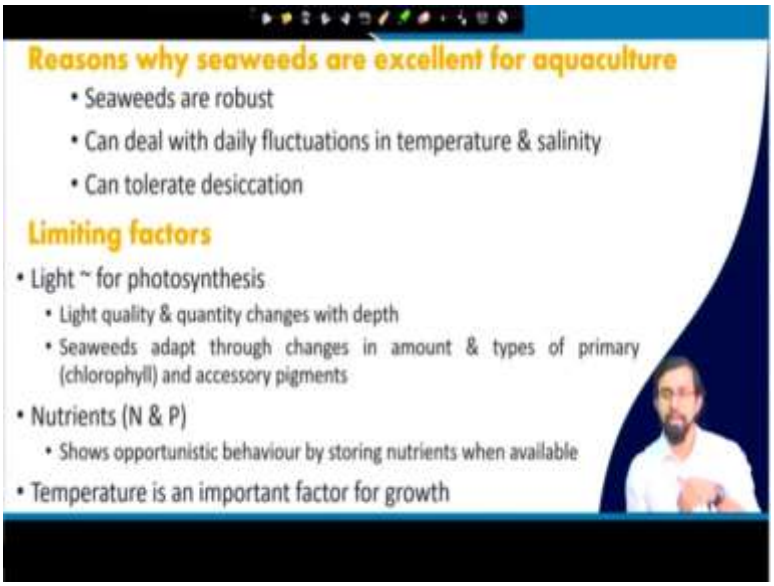

So, reasons why seaweeds are excellent for aquaculture? First of all, they are robust, they can deal with the daily fluctuation of temperature and the salinity; and they can tolerate the desiccation, means the dryness. So, these seaweeds, we can use it can it can it can, we can easily sustain this and seaweeds can easily sustain a major changes in the environmental parameters; and which will definitely be a positive point, a positive side for production on the seaweed. And which will give us a additional benefit when we go for the farming of seaweed in our aquaculture farm.

So, definitely we do not have to worry about much; because if for some reason, there is a minor environmental changes. It will sustain, it will not just wash out like other aquatic sensitive aquatic species. What are the limiting factors? Definitely the light, you have to have a proper ample amount of luminosity have to provide them, so that the light is ample enough for them to grow. For them to photosynthesize, the quality and the quantity changes with depth definitely. So, you have to you have to make sure that you are maintaining a shallow depth or you are culturing in in a shallow depth of ocean for the culturing of these kinds of seaweeds.

Seaweeds adapt through changes in amount on the types of primary chlorophyll and accessory accessory pigments. So, the nutrients that are very important factors; nitrogen and phosphorus sources has to be there in the dwelling area. So, this is actually very much easy once we go for this multi-trophic aquaculture systems. And in case of this integrated multi-trophic aquaculture

systems, what we do? We can grow fish along with the seaweed. So what will happen? The fish it will produce a either excreta or uneaten fish.

It can easily convert into the beneficial nutrient that is new that is needed for the seaweed or any kind of microalgae or macroalgae to grow. And it shows the opportunistic behavior, opportunistic behavior by storing the nutrients when available and they can; so that is also a good thing. So, for long say suppose in between the farming procedures for a certain moment of time, you cannot provide the system with the ample amount of nutrients. But, the amount of nitrogen and phosphorus that they have stored previously during the ample supply of those nutrients, they can easily sustain for a couple of days, a couple of weeks based on the type of the species.

So, that is the good thing about this kind of culturing, this kind of farming practices; that it does not require much of a human intervention. Even some if due to some calamity, you cannot provide them with the nutrient or with the ample amount of inputs; they can still survive till the next application or the till the next supply of inputs. Temperature is obviously an important factor for their growth. So, based on the cultures species and all, they can they have their certain variability in the temperature, they can sustain at different temperature. And based on that we try to incorporate optimal condition, if you are growing it in a tank; and we have to try to put them in a proper optimal condition, so that they will they can easily sustain.

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Major culture groups, these phaeophyta like the brown seaweed; example of which is like Saccharina; I think you guys know about kelp. Kelp is the one which is like very famously used all over the world and kelp has a drastic application in terms of human food like human consumption, in terms of pharmaceutical, in terms of personal care products also. So, there are different kinds of chemicals or the byproducts that can be recovered from the kelp or the Saccharina; and that can be used for this byproduct recovery, and that can be used for these different industries and all.

There is another type of culture groups which called rhodophyta or the red seaweeds. So, the example of it is like this Porphyra and all. There are third but not the last like this Chlorophyta; there is another type of seaweed; the green seaweed we call it. So, famous example of it is ulva or sea lettuce. I think you guys have seen sea lettuce or maybe what sea lettuce. The sea lettuce is actually a type of this macroalgae, it is a type of seaweed, it is a green seaweed. It is a chloro, it is the chlorophytes, it comes under the group of Chlorophyta. So, the culture species for culture methods are there for it depends on the different type of species.

In general, all these three major groups you should remember. And in suppose in Indian context, if you want to go ahead with farming your own farm, or you want to provide the technology to the to your customer who is going to farm in the seaweed, and try to get some byproduct out of it. You have to make sure that what type of seaweed is actually good enough for the production of which target product that you are targeting. And in Indian context, there are certain amount of almost 744 type of species which, if I remember it correctly are available based on the data given by the regulatory bodies in India.

So, they they based on their data, almost 744 species of seaweeds are available in Indian coastal regions, which are their native regions. So, once when they are having these native regions, so definitely they will grow more easily. So, whenever you are you will try to grow some seaweed. In this particular regions, we do not want to go for the exotic seaweed production. You try to find out the production of the seaweed which is native in nature, so that it can easily sustain, easily the production rate will be much higher.

The culture methods, in general 4 type of culture methods are there. In general, we normally use it. First is long-line culture, it is like long main lines will be there; from there, they will be like the subsidiary lines and all, where they will be cultured in a in a long line methods. I will show

you how it looks like. Then, there is net culture, then there is pond culture on the in a stagnant water bodies. And there there come, then there comes the tank culture, where it will be like, it is like regular the water will be moving, and so there it will be culture.

So, long line culture in general, we do it in a natural environment; net culture also we do it in a natural environment. Pond culture definitely in enclosed place in a landlocked body water body, and the tank culture is also enclosed space. But, we provide certain amount of flow velocity for them to for this specific type of seaweed to sustain.

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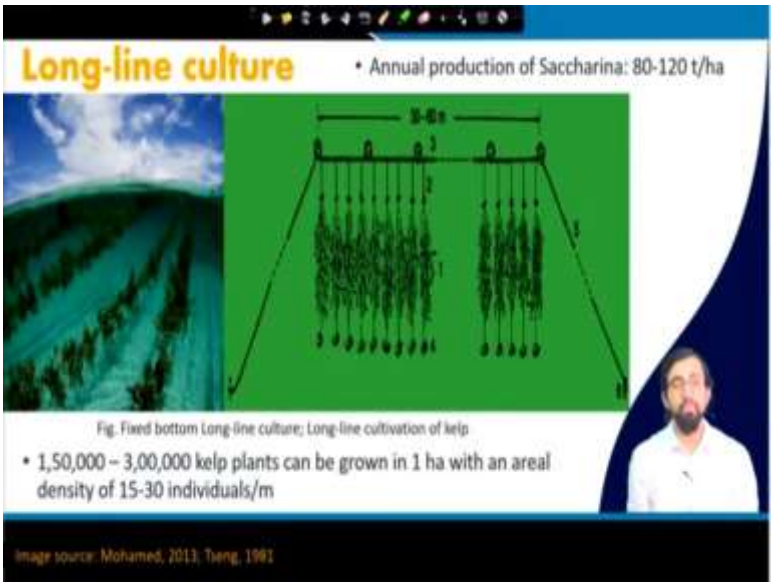

See, this is a long line culture. It actually considers more than 80 percent of the seaweeds that is available, seaweed culture, the harvest, the farming that is practiced all over the world. In this kind of long-line cultures, we have this long liners where these are. You see these floaters and sinkers are there, where because of the sinkers, there is these are in sync in this. In this lines, we have tight tied the seed, we tied the seed in that long lines; and after a certain point of time, say 45 or 50 days in general, that is a standard duration, for which they grow.

After they go, they mature and after then we culture them. So, this is like an old, this is a long-line culture, which is a very famous. This is a very most abundantly used process in case of culturing of any kind of mostly most of the macroalgae; especially, the Saccharina or kelp and kelp. So, this Saccharina annual production of Saccharina is around at 80 to120 ton per hectare that is possible and it cost a lot. So, if you can produce in your farm in a sufficient amount of

Saccharina has a huge amount of benefits economic benefits, you you a lot of economic return you can get out of it; so, it is really needed.

In Indian context it is really needed, people should really think about it. People should really come in the front and start working on this kind of business strategies; and think about the business strategy and go ahead with the culture of this kind of seaweeds and all in India. Almost 1 lakh 50 to 3 lakh kelp plants can be grown in a 1 hectare area with an areal density of around 15 to 30 individuals per meter. And so this is based on the data given by the Mohamed, 2013. There are details of the paper that you can, I will show you at the end of the lecture material.

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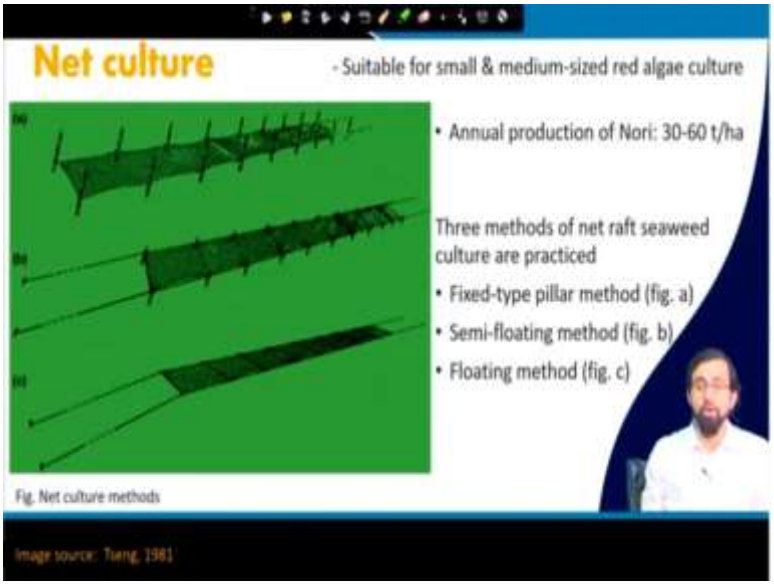

Second is the net culture. It is also normally done in the natural water bodies only, where it is suitable for small to medium sized red algae cultures, especially the nori and all, so porphyra and all. So, this nori in general if see it is like 30 to 60 ton per hectare of annual production can be there. So, this actually this net culture is also like three different types. First one, is it you see it is a fixed a pillar methods. They are like a lot of pillars one after another. So in that pillars, those nets are connected. So, over the net, we try to grow the this nori or this kind of red algae.

So, this is one type of culturing methods. The second is the semi-floating methods, where there will be it is actually floating plus there are some additional pillars are provided to give it some additional strength. And third one is the floating method you see the figure-C is the completely

floating in nature. So, it has connected it is connected from one side, like from the both the side only, there is no intermediate pillars to support its weight.

So, this kind of culture is this based on the type of species, type of red algae or whatever the algae that we are targeting, like when seaweed that we are targeting, we have this three different methods of net culture.

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Then, there comes the pond culture. Pond culture: from the name itself you can understand, so pond. In general, we try to, in general, it has a stagnant water body in general. So, this (glacia) Gracilaria, so this Gracilaria this tenuistipitata so they normally grow in these still ponds. So, for the growth of this Gracilaria, so we go ahead with the go ahead with the pond culture, where there is like we try to go for as stagnant water body as possible. How much yield it is possible? Almost 9 ton, you can see when it is a stagnant water body, when it is like a pond. So, why do not we go for this IMTA this as we discussed?

So, this IMTA in this in case of this multi-trophic aquaculture systems what happened? There, we can grow the grass shrimps or the crab along with the Gracilaria. So, what it will do? First, it will introduce you with a high level of yield, which will give you high economic benefit. Plus, you can properly how to manage eco the environment, you can properly manage the feeding requirement, because whatever the excess amount of nitrogen that is generated in the shrimps by the shrimps or the crab will be consumed by the Gracilaria and all because of their development.

So, by this way we can introduce very standard techniques standard farming practice. So, and it will increase the overall. If you see in case of, if you only produce the Gracilaria, it will give you 9 ton Gracilaria per hectare of per hectare of your farming land or farming pond. In case of if you do it this IMTA, you can have this say 9 ton of Gracilaria along with the 6.3 ton of grass shrimp and crab in the same field. So, it will definitely increase your production is'nt it?

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So, the fourth one is the tank culture, where we have this complete tank culture. We can have a partial tank cultural. These tanks we can provide it in the middle of a pond also, in the middle of a thing. So, when we can have these kind of cultures, we can have it separately in a completely inland pros inland acquisitions techniques; so, where you can have those tanks and which have continuous flow. You can maintain this partial culture is in general the commercial cultivation. Juveniles are produced in tanks before the seeding.

So, what happened because of commercial kelp cultivation? We try to produce the juveniles in the tank first, then we put it in the natural environment in either in net culture, either in the long-liners. So, that is why it is called a partial culture and then there is possibility of complete culture. Complete culture where the from the initial stage, from the seed to the juvenile to the mature stage; all the stages are being all the whole farming is done in the tank. So, that is done in case of concrete culture.

Tank size in general, it varies drastically from the point of view of market expectations, from the point of your species very variety that you are using. From just remember whenever you will be designing in aquaculture farm, you first need to study; first need to think about the target species. Whether that target species is actually viable for production or not; once you target the species, you go for the market study. Whether the market that is available in the near vicinity or even they exporting, export market is good enough and will give you the economic return or not; based on that you design your farm.

Once you have design your farm, you go ahead with the additional; after you design your farm, after you have your product, after you have your market; then go for USP. What is the USP of your product? What will be the something value addition of your product, think about. And then you go ahead with the further business. So, that is how your your thinking should be like when you go for any farming practices; that is how you should go ahead gradually. Think about from the scratch to the business point of view, or scratch to the research point of view. In general, this tank, depth can vary 20 up to from 20 to 30 centimeter.

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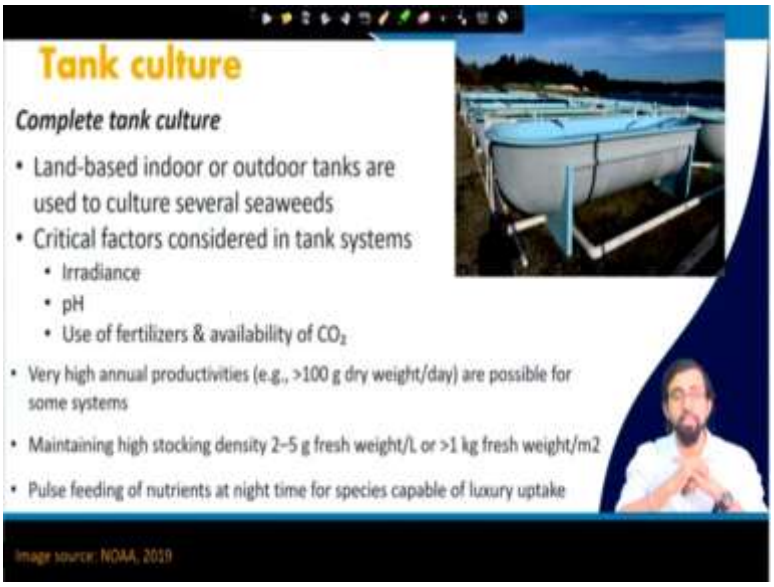

And these tanks can be used for culturing several types of seaweeds, the critical factors that you should we should consider when we will be designing a tank systems. First of all, irradiance. What is the irradiance? Simply the light densities. Because it suppose you are designing a tank which like say a 60 centimeter height, so definitely after 30 to 40 centimeters, the light will not

penetrate. So will it be beneficial? No. Because why to go ahead with the further depth when the light the sunlight cannot penetrate. When the sunlight cannot penetrate, so it will definitely not be it is not be a dwelling zone for your culture species; so, just no we will not go for it.

So, the pH is another factor because based on pH, you have to, you can what you can do? You can do the neutralizing phenomena. If you do not know what is neutralization, you can search for it in Google; it is very important criteria, important phenomena and important system that we normally use process, that we normally use for the treatment of water neutralization. Based on we try to balance the pH that is called neutralization; based on the alkali treatment, acid treatment, we do this kind of neutralization.

So, based on the target species, target pH and also we do this kind of. Sometimes we additionally add some buffers to maintain the pH that is also one type of neutralization technique. So anyway, so think about try to learn about what is neutralization and how it works; it will give you some additional idea about how why pH is important, and how pH is regulated in any farming practices. Use of fertilizers and availability of carbon dioxide; definitely use of fertilizer is very important, because unless until there is not ample amount of fertilizer is available. What do you mean by fertilizer, especially nitrogen and phosphorus?

There are other major elements, there are other minor elements, those are obviously important; but these two are the major factor nitrogen and phosphorus. You have to supply this nitrogen and phosphorus no matter what. How it can be how it can be provided by having this multi-trophic aquaculture as I told?

You can farm your other aquatic species, especially the fish and shrimps et-cetera along with this seaweed. Or you can just provide it in this simply try to have it in estuaries; because in estuary region in the brackish water. There is a high chance of having high amount of nutrients and availability or try to grow it in the place in the coastal regions, where the some of the; there is a high chances of getting a high amount of nutrients available in that region.

So, you have to check the (waste) to check the water quality time to time. And just to make sure that the fertilizers are available, whether it be natural or whether it be artificial. In case of any deficiency in the natural fertilizers, you have to supply it artificially. And the availability of

carbon dioxide it is very simple, definitely the carbon dioxide is like it is like the need need for them to grow, for they will consume the carbon dioxide.

So what you can do? You can simply to increase the carbon dioxide in case of, especially when you go for the natural ecosystem, natural habitat. In that natural habitat definitely carbon dioxide is not a big deal; definitely there there is a chance of having huge amount of carbon dioxide; but, the ample amount of carbon dioxide.

But, sometimes there is a problem we faced where there is, we call this ocean acidification. So, sometimes what we try to do? We try to provide it with some additional material like limestones and all, limestone powder and all. Why to provide limestone powder in the seawater? So, it will increase the carbon dioxide intake rate and it also it will tackle with the ocean acidification issue. So, that is the major problem nowadays in the ocean. So, we can do, we can artificially increase the ocean alkalinity. So, by why by means of providing the limestones by means of providing the other other elements; so that it will increase, it will react with the carbon dioxide.

And not only react with the carbons it will uptake the more amount of carbon dioxide from the resource; and not only that it will somehow manage the ocean alkalinity as well. So, that is one way of capturing carbon dioxide. But, that the all the carbon dioxide that has been captured in this particular sense is actually been converted into; it actually reacts with the ocean acidity and converted with alkalinity, but, that is a different issue. In general, this is one of the process by which we try to grab more amount of carbon dioxide from the atmosphere, and try to fix it in the in our dissolve, increase the dissolved carbon dioxide concentration in the water; by which we can the plant can consume that carbon dioxide as well from the system.

Very high annual productivity are possible in this in for some systems, especially if you go for this intensive tank microalgical macroalgae algal cultures. As high as almost more than 100 gram of dry weight per day is possible. So, the more the production, the more the economic return that you will get from your farm, so, that is good; that is why I always mentioned, think about it. Whenever, you will be designing a farm, go and talk to the experts; and design it very scientifically as minutely as possible.

In this particular subjects, in this particular course I can, I can give more details about all these designs and engineering specifications. But, we have a limitation in times and I cannot go. I have

to cover all those things, so I am not going into more details of these things. So, but provided an opportunity in maybe next later in other subjects; I will discuss more in details. Or you can reach out to me for discussing about how to go for this designing of particular farms. Very maintaining the high stocking density is possible in this kind of culture systems. Almost 2 to 5 grams of fish, fresh weight per liter or more than 1 kg of fresh weight per square meter is possible in this kind of tank system and higher tank system.

Pulse feeding of nutrients at night times for species capable of luxury uptake. So, that is a that is a additional benefit. In the night time also if you provide artificial illuminations, like luminescence maybe in like artificial irritation or light or you are providing. Because of that, you have to somehow replicate or somehow mimic the natural sunlight. And if you can provide it with the LED system to your seaweeds and all, they will still continue doing the photosynthesis. What does that mean? The more they will do photosynthesis, the more they will consume the carbon dioxide; and more they will convert into the available biomass.

So, simply but, so there are scientific limitations for this kind of processes as well, I am not going into details. So, in general the more amount of sunlight is available, the more amount of photosynthesis will take place. And simply the biomass conversion will take. The biomass conversion means what? They will get matured very fast. So, once they will get matured very fast, it will definitely increase your economic return, it will increase the overall output of your farming system.

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So, that is what all about the seaweeds and all; so, I can discuss more in details later on. So, in general, the oyster farming's next topic that will be discussing today is in brief is about the oysters. So, oysters can be of different types like edible ones like cupped oysters or flat oysters. It is very delicious, believe me it is it is very delicious to have the oysters. And that is why it is becoming very famous seafood matter, and it is very exotic. Not in terms of why I call it exotic, not in terms of from it can only be done outside in a specific temperature.

But, also because of its high nutritious value and all, and it is considered as a very standard food practice in Western culture. And nowadays in India also we are started having these oysters. It is there for long, but this culture is getting bloomed easily; it is very fast nowadays. Next is the pearl oyster. Pearl oysters are the one which is and tropical in nature or subtropical in nature, you cannot normally find it in the temperate region was much. But, now they are growing it in artificial environment. So, normally they are tropical or subtropical marine species according in a range of habitats from silty sea beds to the coral reefs.

So, this inner shell layers with the nacreous layer which we call is very lustrous; and is this is the basis of the pulp production. In case of oysters, this nacreous layer is the one where they produce this instead we put the nucleus; and there we have this pearl production. The pearl oysters are a very high value product species; I do not have to say what is the reason. Pearl it is one of the precious, one of the finest of the natural gemstones that is available; or like natural not

gemstones like nature. I mean like jewelry products and all can be made out of it; and there are a lot of other benefits also, not only the jewelry.

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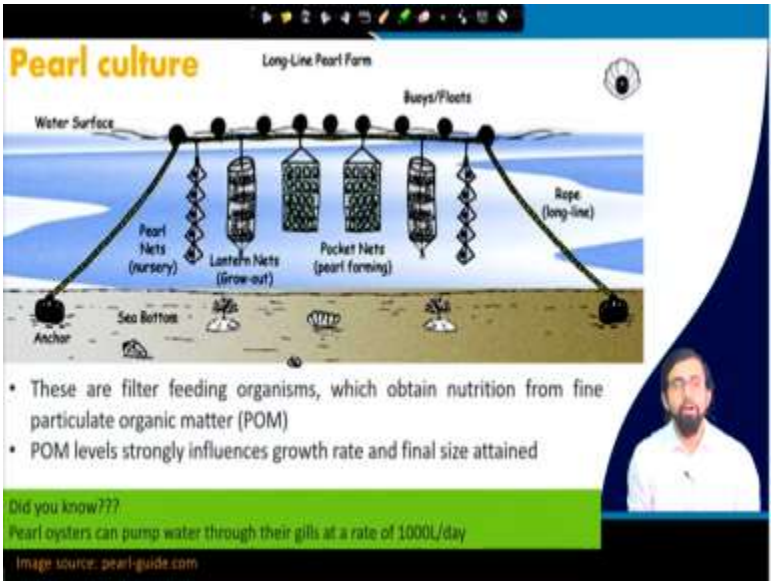

So, in case of long-line pearl from if you see the water surface, the buoys or the floats are there. Then, there is a sinkers and the ropes are connected with the sinker or the anchored to the bottom of the sea, or bottom of the water body, where it wherever you are culturing. There, this pearl nets you see the nursery, the pearl nets how it looks like, then when it becomes at a certain stage, it goes convert. We put it in a lantern nets, where it is work as a growout pond for them, growout region for them.

Then, we transfer to the pocket nets, where actually this pearl farm the proper farming of until the maturation stage, we put it in that pea-nut pearl pocket nets. So, there from there we collect those pearls and we we collect those pearl oysters; and we use it for use the try to harvest the pearls from there. So, there are they normally are the filter feeding species; so, they normally obtained the nutrition from the fine particulate organic matter. So, this POMs this fine particulate organic matter level strongly influenced the growth rate and the final size that it will attain.

So, it can pump the water through their gills at the rate of almost thousand liter per day; so, it is it is really a lot, it is really a lot. And not only that it will it will actually somehow help the environment to get rid of those oyster, to get rid of those suspended particles from the atmosphere, from the surrounding ecosystem.

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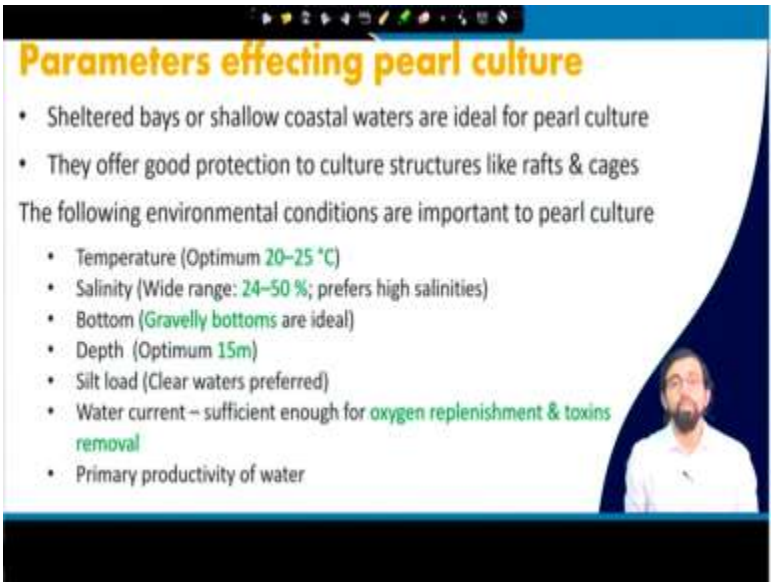

The parameters that affect the pearl culture are the sheltered bays or the shallow coastal waters are normally ideal for pearls culture. Actually, they offer a very good protection to culture structures like rafts or the cages. Environmental parameters that are very important for pearl culture are the temperature 20 to 25 degrees Celsius; I told you like temper like tropical and subtropical water bodies are best. Salinity a wide range up to 24 to 50 percent is preferred it prefers the high salinity.

The bottom like gravelly bottoms are ideal for them; the depth almost optimum of 15 meter. Slit load, they prefer the clean water; it is like the as the clean water is possible is there. And they from there itself they can consume the particular organic matter is not a big deal. The water current is sufficient enough for the oxygen replenishment; because it has to be a little bit ample enough for them to have they; because they are filter feeders. So, for them to have a sufficient amount of oxygen, you need to have a very small amount of water current availability for the oxygen replacement.

Or you have to supply it with additional means; you go ahead with the filter aerators and all. Primary productivity of the water is very important, because they they actually consumes those planktons and all to go ahead with the; they are the primary producer. So, that that that is what I mean that is what it means here by the primary productivity.

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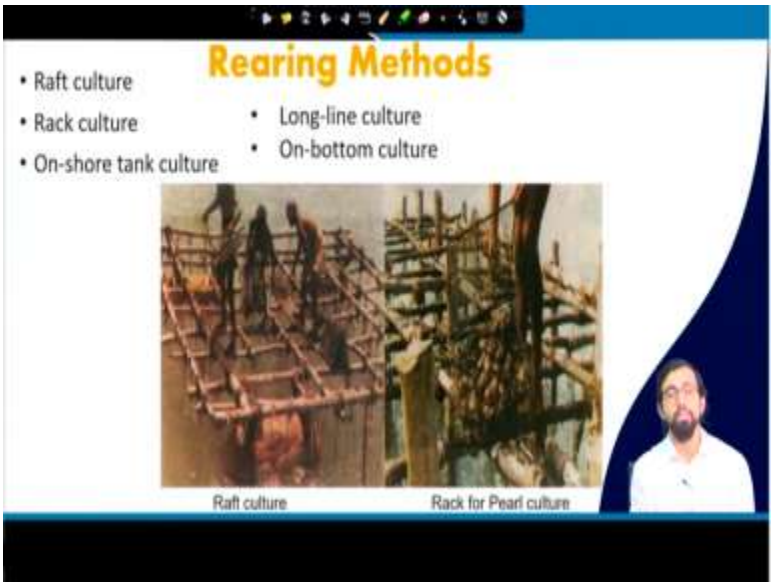

In general, the rearing methods, there are raft cultures, rack culture, on-shore tank culture, long-line culture, on-bottom culture. We have already discussed all these things like how how it looks like; so, you might have already have an idea how it looks. If you see the raft culture, you can have a bamboo wrapped, which like this square pattern and then or the rectangular in pattern. You can put the linings along with it and you can have the raft culture, you can see the rack. These racks are provided in this rack of pearl which are provided, and will hang through this racks in a therefore for the high precision pearl culture.

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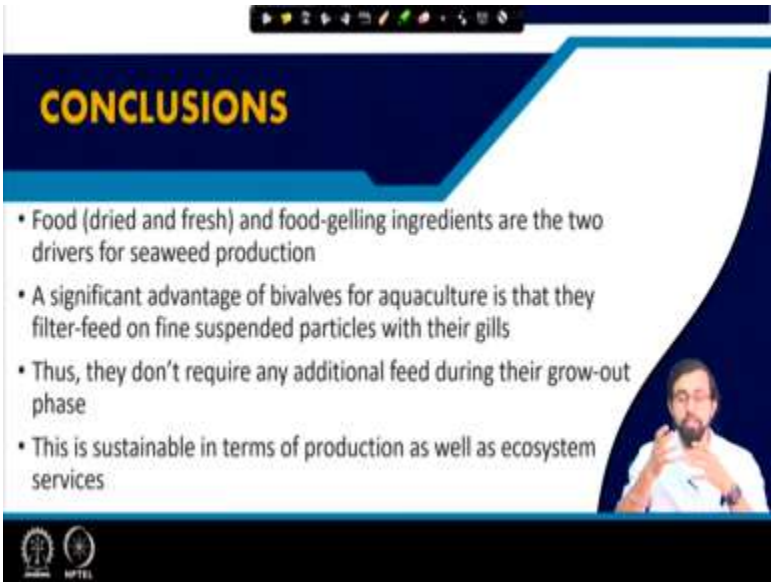

We have this conclusion like to conclude this lecture; I would say like this dried and the fresh foods and the food eating food-gelling ingredients are the two drivers for the seaweed production. A significant advantage of bivalves for aquaculture is that they filter feed on fine suspended particles with their gills, which will increase the environmental sustainability, and also your production rate. Does they do not require any additional feed during their growout phase. This is sustainable in terms of production as well as the ecosystem services.

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So, what is the takeaway message from this lecture? The aquaculture of seaweeds and the bivalves are highly beneficial to the habitat to this ecosystem, to the human, for human economy or the country's economy; for definitely to eradicate the unemployability issues. It is it is actually the future, it is like people should really think about it and find a way to go ahead; and go and start your business on these kinds of sectors. This is blooming in future like anything, the production of these organisms, help in creating the aquaculture water as well as earning a better livelihood as a livelihood as I just mentioned.

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So, these are the references that I have taken the same materials from, so maybe you better go ahead and visit them to get some more knowledge on this sector. Or definitely in that case, I am always available; you can reach me out with the video with the mail-id. So, thank you so much; that is all for this lecture. See you in the next lecture. Thank you.