

**Advanced Aquaculture Technology**  
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**Lecture 06**

**Transformation of Open Culture to Closed High-Tech Technologies**

Hello everyone, welcome to the next module of Advanced Aquaculture Technology. So in this module we will be learning about the technology of closed aquaculture systems and in this first lecture I will be discussing about the transformation of open culture to closed high tech aquaculture technology.

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The concepts that will be covered in this particular lecture will be the types of aquaculture systems, open aquaculture systems, the demerits of OAS, the closed aquaculture systems and

the key elements of this CASs, how this this closed aquaculture systems can mitigate the inadequacies of the open aquaculture systems. So to start with we know the different, various types of aquaculture depending upon the hydrobiological features, depending upon the motive of forming and the depending upon the social operational technique that we will incorporate. Okay!

So, when we talk about the in general the various cultural practices are there all over the world which we normally follow and which we normally consider as the various types of aquaculture systems and in generally is as follows like first of all the Mariculture, the mariculture it involves any kind of aquaculture practices which involved with the sea water. Okay!

So, it can be mostly in the sea basin it can be done; it can be done on the open sea, it can be done on the the bank of the sea where we will be doing like you know will be digging a proper canal and will take the sea water through it and so that water can be utilized for the say like this tide fed farms and all.

It can be of flow through or the raceway cultures, so in recent days these technologies are evolving like anything and especially these raceways and all I will be discussing in details in later lectures how the raceway technologies is actually revolutionizing this aquaculture practices all over the world.

The third is the algaculture, mainly in the algaculture mainly we talk about the seaweeds and all. So there are other aquatic plants as well but the seaweeds are the one of the most talk about and we normally try to grow all over the world specially it is the it is considered for their its high nutrient which is very much a utilizable for the pharmaceutical and as well as the personal care products and not only that this seaweeds are very much famous in the south like eastern part of the asia especially in Japan and all and even in the European region even if you go for the more western US and all, there also people prefer seaweeds.

Even in India also people started favoring seaweeds and all as a human consumption, so which is used to make the sushi and all you know it! this Japanese dish and all. The There are types like integrated multi-tropic aquaculture, what does that mean? It means the multi-tropic, from the name itself we can say it's not concising on a particular tropic of us a food hierarchy rather or the food chain we can go for the multi-trophic culture. Okay!

So in case of multi-tropic cultures they we can go like there are various type of examples we can give the rice and fish culture, the integrated rice fish duck culture, the integrated poultry and fish culture so there are; just to name a few. So this type of culture procedures we normally consider under the integrated multi-tropic aquaculture.

Inland pond culture which is very famous for like thousands of years from the beginning of the human civilizations. We now it is it that we started incorporating very high-tech aerator systems very high-tech intensive aquaculture techniques so to improve the cultural benefits or cultural yield out of it.

Recirculating systems, the recirculating aquaculture system is one of the recent technology, recent days technology which we try to incorporate you know to get rid of the water the loss incorporate because of the change of fresh water very frequently. So what we can do we can go ahead with the treatment of the aquaculture waste water and then we get it back to the pond itself or the tank itself, so this is called the recirculatory aquaculture systems by which we can reduce the consumption of the overall water from the like overall water demand.

Then there comes the open net pen or the cage systems, so this open net pen and the cage systems they can be done in the say like so any kind of surface water bodies it can be done in the river systems, it can be done in the sea water and I mean like in the ocean bodies, open sea or maybe the or in like the offshore areas even we can do it the pen cultures can be done in the by the side in the bank areas as well. So I mean like in general these are only a to name a few different kinds of practices different types of aquaculture that we normally have in incorporate in the aquaculture topic in general.

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## Open Aquaculture System [OAS]

- Involves rearing of aquatic organisms within enclosed systems, in natural environments like *freshwater rivers, coastal marine regions and brackish estuaries*.

• Types

- Sea-cage (active-feeding)**
  - Utilizes floating mesh cages anchored to the seafloor.
  - Seabream, seabass, codfish, tilapia, salmon, and shark catfish* are some organisms cultured in such OAS.
  - Cultured species rely on a *fish-meal diet*.
- Sticks, racks, ropes, and cages (passive feeding)**
  - Utilizes sticks, ropes, or cages as modes of attachment.
  - Mainly cultured species are *mussels* and *oysters*.
  - Cultured species are *filter-feeders*, doesn't require fishmeal diet.



There are open aquaculture systems or OAS in short, so this actually involves the rearing of aquatic organisms within an enclosed systems, but in natural environment okay say like in freshwater rivers, coastal marine regions, brackish estuaries, etc etc. What we normally do we try to develop a proper say cage or pen culture or say like rope even stick is also involved so this kind of structures we involve and what we do we try to use it in the natural ecosystem natural environment and try to grow our target aquatic organisms.

It can be of active feeding type, it can be of passive feeding type; active feeding type are the one which is like the sea-cage normally where we utilize the floating mesh based cages which actually anchored to the seafloor. When we anchor this kind of sea cages and all this cage cultures and all which we normally use seabream, seabass, the codfish, tilapia, salmon, shark catfish, etc.

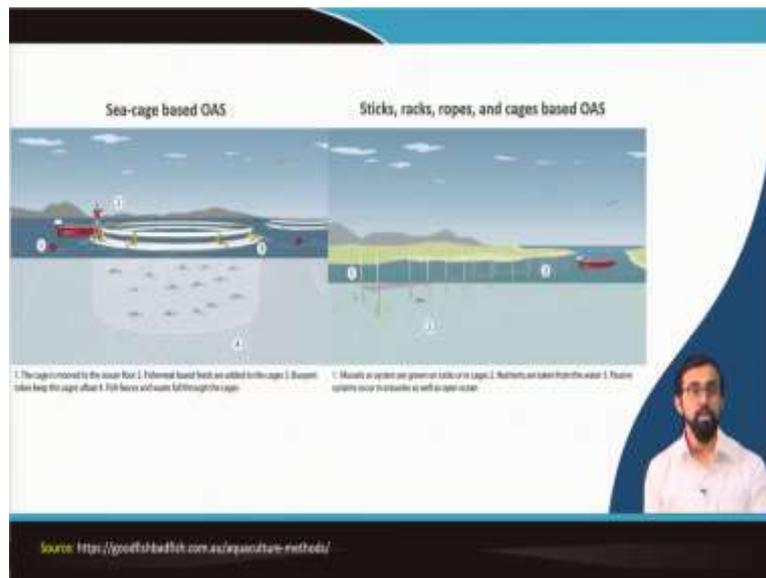
So this kind of fish this kind of this aquatic or aquatic animals, this aquaculture species can be cultured in this kind of open aquaculture systems. However, the main difference is like main thing is like here in this kind of culture with this kind of targeted aquatic species we need to rely on the fish meal diet we need to provide them with the fish meal like additionally, okay so that is the thing.

No though No matter it is actually cultured in the natural ecosystem but still it is actually completely like not completely or semi completely rely on the the active feeding or the feeding the feed that you are supplying to the system. Second type is is the passive feeding, all the stick, racks, ropes or cages that you can provide and in this kind of arrangements what happened the mussels and the oysters what they will do or even like the seaweeds and all

what they will do they will just grow over its surface and they or what will happen they are mainly the filter feeders.

What they do they completely take the water of the surrounding places and they filter it through their through the specific like system that they have in their body and because of that what will happen whatever the planktonic organism that is present in the water, whatever the amount of water they in intake so they can easily filter it out and they can utilize it as a diet. So for this kind of aquatic species we do not have to rely on the additional fish meal diets.

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You can see in this picture the first one if you see the sea-cage based open aquaculture systems where you see the the cage is actually moved to the ocean floor and the fish meal is provided artificially you can see the number two so it's provided artificially which is added to the cages and this buoyant tubes are there to keep the cage upload or we sometimes call it floating tubes as well, floaters as well.

And the fish, you can see the amount of loss it can cause the all the fish pieces and also the waste or the uneaten feeds actually what happen they will directly fall through the cages, because it is a mesh kind of structure there is no solid floor. So because of that there is a huge amount of loss of uneaten feed or the fish excreta that is actually being there which can cause local environmental impact as well.

So we will discuss about it in details what are the cons part of it what is the disadvantages of this sea-cage based OAS, and you can see in the second figure like the where stick, racks, ropes or the cages are used where the oysters and mussels can grow on its surface on its body and see the nutrients are taken from the water by the organism itself and the passive systems of this kind of systems can occur can be utilized in the estuary region as well as in the open sea region. What are the demerits of this open aquaculture systems?

First of all there are the open aquaculture system that the demerits means whatever I want to discuss is the one which normally used conventionally but nowadays because of the scientific advancement we kinda of get rid of all these problems and we try to find out the additional solutions out of it. I will be discussing all all these things in later lecture like what are the advancement in the OAS systems even which can also reduce that these demerits that I will be discussing right now.

So first of all in case of OAS the first is active feeding one we required to we need to provide them with the fish meal for feeding the carnivorous species; we need to provide it the normal meal also like in case of other species. The poor conversion ratio sometimes even 5 kg of fish meal is required to breed only 1 kg of fish because of the loss of huge amount of loss that incurs with this kind of structures with this kind of infrastructures.

High fish density results in the increased amount of disease and the parasite transmission and because of we are utilizing it in a normal environment to increase the yield we may sometimes normally go for the intensive aquacultures practices in this kind of OAS's and all. There is a risk of escape if by any natural calamity or by say like any predators and all somehow if this this came the netting material the mesh is somehow getting like a tear apart or it gets broken what will happen there is a chance of loss of huge quantity of economic loss can be happen. You know there is the whole fish school of fish can escape through it and because of that you can it can cost us a lot of economic loss or economic disadvantages.

So, another unwanted thing is like inter breeding with the wild populations because sometime these meshes are all from the upper part of it is open, so sometimes because of the flashing of water or like the waves the oceanic waves or the river waves it will there is a chance it can contact with the wild population and once it is in contact with the wild population it can inter breed with them and this inter breed can cause harm to the system as well. There are a lot of case studies happen where this inter breeding actually caused the huge harm to the local ecosystem and well therefore we do not expect it to be happening in our farm.

Accumulation of the fecal waste which reduces the water quality as I discussed it you can see in the picture only the all the feed that we are supplying it is not being completely eaten by the fish because it cannot, so some of them get, as well as this pickle waste pickle waste is like the fish excrete or the whatever aquatic species you are targeting the excreta of that particular excreta of the excretory products of the species that also can has a huge amount of nitrogen in it which can cause the water color to deteriorate, isn't it? So these are the problems other than that disposal of sticks and racks also can be a concern can be a matter of concern in some areas which are normal practice in case of open aquaculture systems for growing the mussels and the oysters.

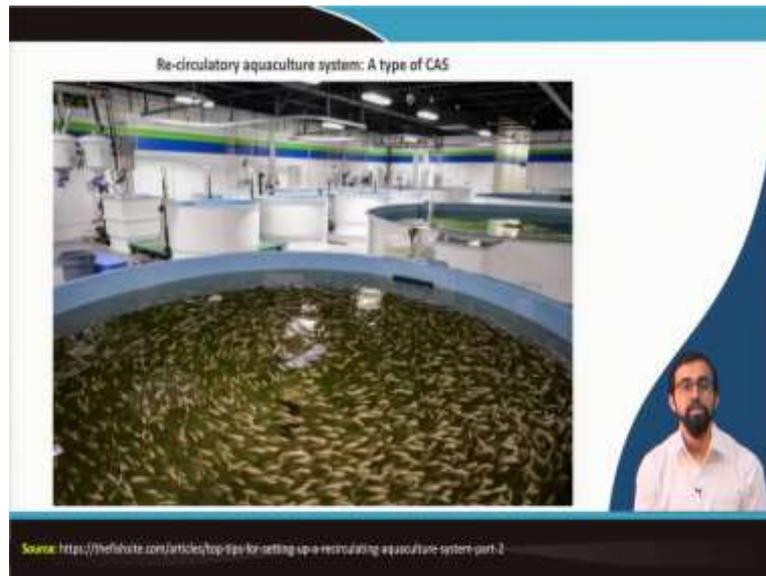
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### Closed Aquaculture System [CAS]

- Involves land-based breeding of aquatic organisms in *ponds, raceways, and tanks*.
- Maintains a controlled interface between the reared species and the natural environment
- Implements a highly sophisticated waste management procedure that filters the generated wastewater and cycles it back into the aquaculture system.
- **Recirculating aquaculture system** is a typical example of a CAS.
- **Atlantic salmon, Cobia, Catfish, Tilapia, and European bass** are some aquatic species reared in CASs.

SEMI-CLOSED AQUACULTURE SYSTEMS      CLOSED AQUACULTURE SYSTEM

Source: <https://goodfishandfish.com/aquaculture-methods/>



So let's discuss about the closed aquaculture system, so we know what is open aquaculture systems like you know we had an idea about what is close aquaculture but simply it is nothing but which involves the land-based breeding of the aquatic organisms in pond, raceways and tanks. It maintains the control interface between the rare species and the natural environment; so once we can maintain this controlled interface between these two features what will happen we can easily optimize the benefits, we can easily reduce the environmental impact, we can easily increase the yield. So all together this is a win-win situation for us. So, this in general we implement the highly sophisticated waste management procedures which can filter the generated waste water and cycle it back to the aquaculture system itself.

Recirculatory aquaculture system is a typical example of this closed aquaculture system. Atlantic salmon, cobia, catfish, tilapia and European bass are some of the example of the aquatic species which are normally reared in the CASs like the closed aquaculture systems.

Here in this picture I have shown you the what is semi-closed aquaculture system and what is a closed aquaculture system. In case of semi-closed aquaculture system you see the inlet; for the inlet you can see the red pipe which is actually used with this conduit line is actually used to take the water from the sea or the ocean water then it is pumped to the system and that water that water is utilized in the prawns are actually normally cultivated using this method and this semi-closed aquaculture systems the best example of semi-closed aquaculture system is tide fed farm or even the pump fed farm.

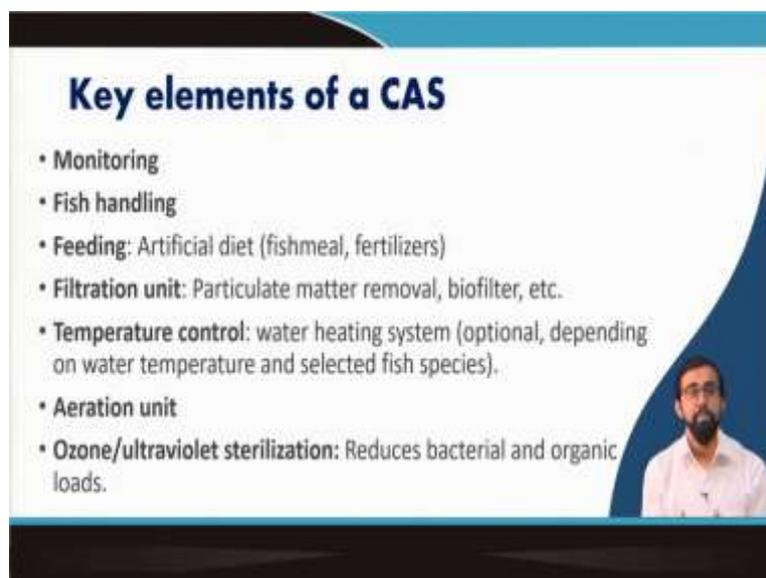
We call it pump fed farm because like pump fed brackish water farm our pump fed seawater farm so because this kind of culture spaces it needs certain amount of salinity. We know that

sea water has like around 30 to 35 ppt of salinity, in case of brackish water it can be like as low as 1 to 2 ppt, as the high as say like 10 ppt of salinity.

So, that salinity has to be maintained, Okay! and this kind of aquatic species can only be sustained in this kind of when the medium has this much of salinity. So, in order to grow them in order to culture this kind of species we normally go for semi-closed aquaculture systems and the closed aquaculture system is you all know like it's like a simply a closed place where we are supplying the additional feed and all and we try to grow the aquatic species out of it.

Recirculatory aquaculture system it's a famous example of this closed aquaculture systems where we try to grow intensive in intensive nature the large amount of aquatic species in a small enclosed space and we try to treat the water using different methods, I will be discussing soon what are the methods that we normally use. So by treating it then we, just after the treatment is done we just let the water come back to the pond itself , comeback to the tank or raceway or the pond itself, so this is called the recirculatory aquaculture system.

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**Key elements of a CAS**

- Monitoring
- Fish handling
- Feeding: Artificial diet (fishmeal, fertilizers)
- Filtration unit: Particulate matter removal, biofilter, etc.
- Temperature control: water heating system (optional, depending on water temperature and selected fish species).
- Aeration unit
- Ozone/ultraviolet sterilization: Reduces bacterial and organic loads.

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What are the key elements of CAS, what are the key elements of closed aquaculture systems? First of all we can monitor it, we can monitor the fish health, we can monitor the water quality, we can monitor the amount of feed requirement, we can monitor the environment of the surrounding temperature like even the temperature of the air also does matter so all these things can be monitored because of its because in anyway it's in the controlled atmosphere, it is in the controlled greenhouse, it's in a under control say like concrete house or even if it is in the open open air but still it can be controlled and we can put a roof on it and we can

control the environmental the environment of the the surrounding vicinity and we can also control the water or the tank water or the raceway water in this kind of systems.

Fish handling is very easy because the catch is very easy you can just go for it and just have a small net and you can easily catch it, you don't have to worry about catching fish because of its height it can be larger in size the pond or the tank can be larger and huge size in in nature but still it is doable the catching of fish is much easier and time to time you can collect them and you can check their if they detect the diseases, if they it occurs, you can detect the growth rate and you can have a proper understanding about the your target aquatic species in general. Feeding habits completely artificial that it will depend in general, so you have you can go for fish meal, you can go for fertilizer, you can go for the other diet as well other like feeding arrangements as well.

The filtration unit in general we try to get rid of all the suspended solids from the system and then we go for bio filter to treat the the nitrogen species and try to get rid of all the nitrogen species possible from the system. Temperature control water heating system it requires I remember I told you about I think in previous to previous lecture where we were discussing about the geothermal energy.

We use the geothermal energy in general or if we cannot if we cannot have the access to the geothermal energy what we can do, we can simply use a temperature control atmosphere or temperature control greenhouse so that the temperature will can be controlled inside your systems, because what happened even in like forget about the temperate region there we definitely have to have a water heating system.

Even in region like us like even in India also if you go to the northern part of India go to the northern part of West Bengal itself in these regions so what happen the temperature is very like incase of the winter the temperature goes down drastically so in order to culture a particular type of culture species year long what you need to do you need to maintain the temperature for them to survive in that system.

So that is why we need to go for the controlling of temperature and controlling of proper environment for your cultural species so that's why you need to provide the water heating system. That's kind of disadvantage of this type of systems but just imagine what will happen in case of open aquaculture system, in case of open aquaculture system you just cannot like culture it at all, in case of closed aquaculture system you can at least culture them, you can at least culture them providing some additional means of support, Okay! but in open

aquaculture system the nature nature is in super harsh in case in the winter season because especially in terms of temperature and if you go to the temperate or further above in the northern part or say below in the southern atmosphere what will happen it is really not possible for them to grow any kind of species there because of the temperature.

Unless there are some certain species which are actually available which can sustain this cyclophilic temperature but normally they are not. Aeration unit so you need to provide aeration area that's actually one of the nuisance for this kind of stuff this kind of technology that you need to provide aeration you need to provide the dissolved oxygen artificially for your culture species to grow otherwise and also you have to maintain that dissolved oxygen all the way long.

Ozone and ultraviolet sterilization it reduces the bacterial and the organic load sometimes we incorporate in a recirculatory aquaculture system this kind of ozone or ultraviolet sterilization which before putting that water back to the system so that we can get rid of all the pathogenic microorganisms from the system even if it grows we can easily get rid of it by utilizing this ozone or this kind of tertiary treatment units.

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**What makes CAS better than OAS?**

- Maintains water quality due to **negligible interference with natural waterways.**
- Sophisticated **waste management procedures.**
- **Prevents fish escape** to surrounding waters.
- **Reduced transmission** of fish diseases and parasites.
- Improved fish quality and **superior growth rates**
- **Better food conversion efficiency**
- Reduced dependency on therapeutics.

The slide features a blue and white color scheme with a curved design element on the right side. A small video inset in the bottom right corner shows a man with a beard and glasses, wearing a white shirt, speaking with his hands clasped.

**CONCLUSIONS**

- Open Aquaculture System (OAS) has been the most preferred aquaculture system over the years.
- OAS, however, possesses high environmental risks due to its direct contact with the natural waterways.
- Thus, the focus has now shifted towards closed aquaculture systems (CAS).
- CASs involve highly sophisticated waste management systems for solid waste removal and biological filtration, thereby improving the water quality and making the water reusable several times, before being discarded.

Logos: IANIGLA, INTA

So what makes this CAS better than OAS like this closed aquaculture system better than the open aquaculture systems, I think with whatever I have discussed till now you will have a better idea about what exactly it means and why I mean by this particular slide that why like CAS's is somehow better than the conventional OAS's that is available in existing models that is available.

In general it maintains the water quality due to the negligible interference with the natural waterways, you can have a sophisticated waste management procedures you can prevent the fish escape through to the surrounding water which is one of the major issues which we normally kinda face in when we go for the open aquaculture system.

Reduce the transmission of fish diseases and the parasites because as I mentioned like we use different techniques, tertiary treatment techniques to reduce the microbial load of the water or the waste water. So when we try to reduce the microbial load of the unwanted especially the one we call it the pathogens when we try to reduce the amount of pathogens or if any unwanted microorganism in your system we try to reduce the load by using the additional means we use the different tertiary treatment methods like we can go for ozonation, we can go for uv treatment, we can go for activated carbon filters and all so like this is just I'm giving some examples what which normally use.

We can go for advanced oxidation processes where in we can go for we can use the catalyst different photo catalyst along with the UV, so it will further increase this reduction in the microbial load process from the process. These are different technologies which are already available and which requires very less amount of energy with the advanced technology that is

already there in the market and it can reduce the possibility of transmission of diseases and parasites.

See, there may be some additional cost involved with the application of this additional technologies however just remember once your culture species get the disease or somehow it get the infected with the disease in a very short period of time you will lose the it will have a very huge economic impact in your farm.

That is why we need to we need to go for this kind of treatment system so that it'll improve so there will be a continuity, like atleast you will have a better control to your system to reduce the any possible disease outbreak in your farm. It improve the fish quality and the superior growth rate because your each and everything is well controlled, well optimized and it is done in the scientific way. If it is done in scientific way definitely it can improve the fish quality and it can improve the growth rate like anything.

Better food conversion ratio because your the amount of fish feed that you are supplying the amount of uneaten or uneaten fish feed we can reduce it by providing by do the proper calculation and we can go for exact amount of we can produce the feed which is having exact amount of nitrogen or phosphorus that is needed for the fish to grow.

We don't go for additional amount of nitrogen, we do not have to go for additional amount of feed, because in open sea what happened there is the flow of water and also all most of the feed is getting uneaten but in case of closed aquaculture systems even if some amount of feed get on it and at the initial stage of employment but afterwards the fish will come and when it will be hungry it will come and have that food, like I am just giving you a scenario so by this way the food conversion efficiency can be improved.

It reduce the dependency on the therapeutics and different kind of antibiotics and all whenever this kind of open aquaculture systems they kind of, how to say um sorry say closed aquaculture systems and reduce the need for these all the systems because it can reduce the possibility of disease outbreak and all and when there is a decrement or the like when you can reduce the possibility of disease outbreak and all so definitely it can help you out with the it can give you a better average better advantage than the open aquaculture systems.

So to conclude it the open aquaculture system has been like most preferred aquaculture systems over the years, but however it possesses high environmental risk as we discussed due to its direct contact with the natural waterways.

Thus, the focus has now shifted towards the closed aquaculture systems mostly, however, I am telling you there are recent studies there are recent researchers going on even on open aquaculture system also to make it more viable, to make it more environmentally benign so that it will not cause this much environmental risk or it will still it can give the proper the benefit that we are looking for. Okay!

The closed aquaculture systems it involve highly sophisticated waste management systems for solid waste removal, biological filtration, thereby it can improve the water quality and making the water reusable several times before being discarded.

So it can reduce the water consumptions like anything but see still I cannot compare in this particular matter with the open aquaculture system because open aquaculture systems we are not utilizing the water at all, isn't it? but in terms of waste management it is much better, the CAS is much better than the open aquaculture systems than all. Okay

So all together there are pros and cons for both of the systems but you need to understand now the science has advanced enough and CAS is not only closed aquaculture systems but even open aquaculture systems are also coming forward with a huge possibility of getting huge amount of economic return with a high production yield and closed aquaculture system definitely it goes a long way now in terms of scientific output and all.

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The slide features a dark blue header with the word 'REFERENCES' in yellow. Below the header is a list of four references. In the bottom right corner, there is a small video inset showing a man with a beard and glasses, wearing a white shirt, speaking. At the bottom left of the slide, there are two small circular logos.

So these are the references that I have used you can take a look on this so that you will have a better idea about the discussions that we have. Thank you so much see you on the next lecture.