



INDUSTRY PERSPECTIVES

16. LATEST DEVELOPMENTS IN LOW COST, LOW IMPACT PHYTOPLANKTON PRODUCTION FOR FEEDING MOLLUSCS AND ZOOPLANKTON FOR THE SHRIMP AND FISH FARMING INDUSTRY, OR: HOW TO PRODUCE IT?

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HETEROTROPHIC OR AUTOTROPHIC?

Heterotrophic production, bioreactors and the like we can dismiss right away. No farmer in his right mind would start up food production for humans or his cattle in that way; so why wish it on the aquaculture industry?

AUTOTROPHIC

Just grow it! Most of the requirements are free. The light, water, CO₂, even nutrients are not expensive. The main ones are N and P, available at A\$300/tonne.

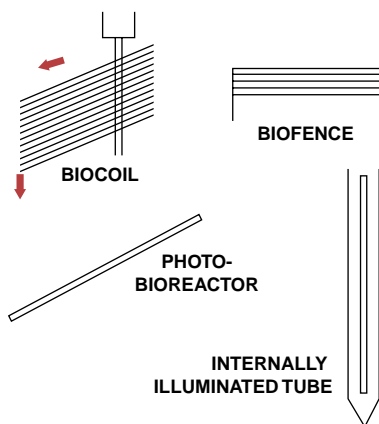


Figure 16.1 Illustrations of a biocoil, biofence, photo-bioreactor and internally illuminated tube.

¹ SeaSalter Shellfish (Whitstable) Ltd. (See details in appendix.)

There are four main strategies to culturing algae — what I call Contraptions, Batch system, Continuous, and Managed Ponds. The Contraptions (Figure 16.1), for want of a better word, embrace highly intensive cultures in small bodies of water. They all suffer the same shortcomings (Table 16.1). Outdoors, or in a greenhouse, they are too unstable and therefore need to be kept in an insulated and artificially illuminated room. This alone means they price themselves out of the market and should be relegated to the laboratory bench. The contest, if there is one, is between batch systems and continuous flow systems.

Table 16.1. Disadvantages of systems competing with the Seasalter Bag Systems.

Disadvantages of systems “competing” with the “Seasalter” Bag Systems .

1. Low thermal capacity and so extremely unstable.
2. Low total volume so that they can not be run continuously unless they are illuminated during the night.
3. Total No. of cells produced is a fraction of what our units produce.
4. None has a foolproof water treatment process .
5. The algae does not have long enough residence time in the system to build up optimum lipid levels
6. To produce more than one species you have to have a separate unit for each one
7. All make heavy demands on power.
8. All of them stand up, so they cost a lot of money.
9. They are conspicuous and so may require planning permission.
10. Difficult to clean.

OUTDOOR LAY FLAT SYSTEMS have zero environmental impact, and are very cheap to install.

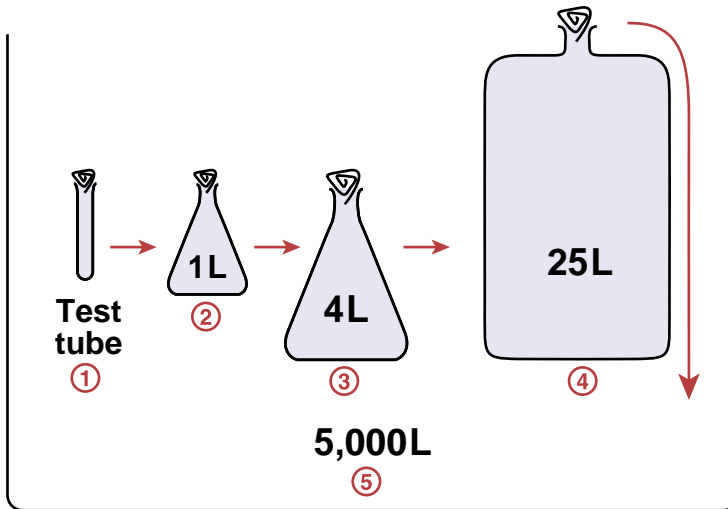


Figure 16.2. Sketch showing volumes ranging from test tube, through 1-litre, 4-litre and 25-litre flasks, up to a 5000-litre tank.

In Figure 16.2, set aside Stages 1–4, and look first at Stage 5. Hands up those of you who can get your batch tanks from inoculation to a useable cell count in less than 5 days. Your tank is out of action for the first 4 and when it is ready you have to use it all. The fact that batch cultures frequently crash means your algae capacity has to be 5 to 10 times that of a continuous flow system. That alone should wipe it out.

But look at this: Items 1–4 are hard work, and cost a lot to set up and run. You need test tubes, lights, shelving, air-conditioning, an autoclave and personnel — at least one person full-time to operate the system, possibly 7 days a week.

Continuous cultures can run for months, even years in some cases. The water supply is so clean that we can start a bag from a test tube if we wish, but we don't, because it would take weeks. The important thing is that the culture in the flow-through system is as good as the starter, so what do we use as a starter? An existing bag! You can do away with flasks and autoclaves completely.

We use polybags because they are cheap and disposable. No need for bin scrubbers. Throwing away a couple of kilos of polythene every few days is

probably more environmentally friendly than driving to work; and using my system will see to it that fewer people do that! The object of the exercise is to utilise, as much as possible, the available natural light — so your algae system could lie flat like a pillow (Figure 16.3). If the CO₂ is added with the incoming water and not mixed with the air, aeration is required only to stir the culture. There must be many ways to do that.

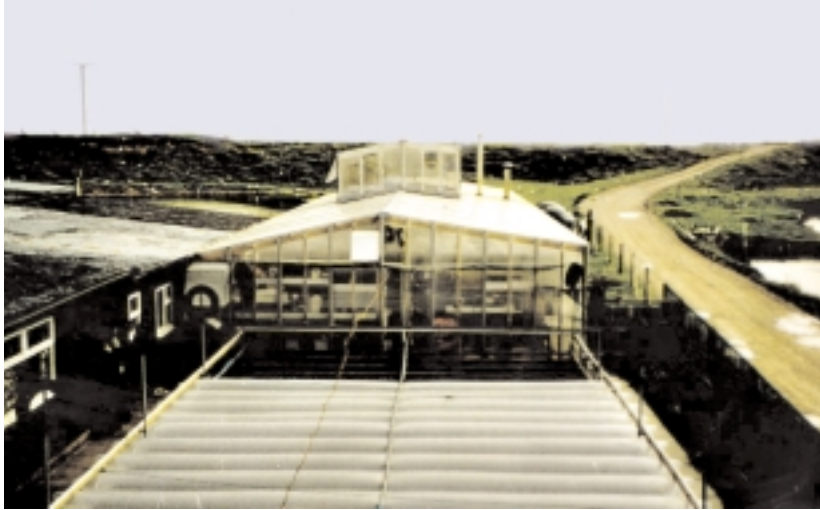


Figure 16.3. Lay flat algal production system.

HOW TO SET ABOUT GROWING MICROALGAE

1. Overcome the low thermal capacity by having most of the water external to the culture. Float the bags in a pond if you like, and perhaps have the pond hyper-saline so that in the event of loss of air, the bag does not sink. Such an arrangement might enable the bag to be agitated, and perhaps circulated other than by aeration. This will facilitate the production of long chains of diatoms, which are easier for copepods to grasp. In summer it could be the cooling medium. Cylindrical bags floating in this way would take on a pillow shape, and it might be possible to gently rotate them, to prevent sedimentation.
2. Retain the high volume by having a greatly increased area while depth is kept to 10–20 cm. It is obvious, from the efforts around to date, that circulation has proved a bit of a problem. First we need to establish the degree, if any, to which this is necessary. If it is, find a means of doing it, perhaps by moving the bag rather than the water. Aeration itself is certainly not necessary, but we have on occasion found that the culture can be less dense at the inlet end than at the harvest end, due to lack of mixing.
3. Use natural light. Assuming that nutrients and CO₂ are in plentiful supply, all cultures are light limited. Using artificial light is a waste of money. It follows that natural light is the obvious solution and yield will be a function of how much surface you can cover and the extent to which you can minimise reflection.
4. Maintain a 4–5 day retention time in the shallow bags. This should not be a problem.
5. Using the above, flexibility of the bag system remains.
6. There are no power requirements, other than for water treatment.
7. The sun shines for an average of only 4 hours a day in east Kent, and even less in Walney. Most of the time algae are supported by daylight, which is diffuse and comes as much from the north as from the south; so pointing the panels toward the sun is a waste of time and, even more importantly, of money.

Lay-flat has all the answers. Just reducing the depth will increase the cell density.

We have algae systems running in many parts of the world. Obviously, in places like Newfoundland Island and northern Norway, the only option is an insulated building; but coming a little further south to Nova Scotia, we are putting up a system in a greenhouse with a special snow-shifting polythene cover. In the UK we can grow algae outdoors most of the time, but it pays to cover the bags during the winter.

In the tropics, air temperature tends to be even. For example, the system in the Philippines is around 32°C, so all that is required is to avoid direct sunlight. South Australian summer temperatures can be higher than 35°C and active cooling is necessary here with shading and mist spray. Rod Grove-Jones, who runs that system, has said that he would be happy to explain it to visitors.

ZOOPLANKTON PRODUCTION

Turn now to zooplankton production. I have approached the subject strictly from a layman's point of view. I have no fish and so I have no requirement for zooplankton. Increasingly, our systems are used by fish farmers.

First, copepods and shrimp. I know very little about these and suspect I am not alone. Copepods crop up from time to time in my ponds, sometimes at high density. Efforts to cultivate them on our algae have been largely unsuccessful. To my eye it seems that the feeding mechanism of both shrimp and copepods is adapted to larger cells, or chains of cells, than we are currently offering. This is the field I wish to explore and a subject perhaps for further research by yourselves. *Skeletonema* and *Thalassiosira* can form long chains but not in the vigorously agitated cultures we are producing. The 'un-aerated' bags referred to earlier might produce a much better food for these crustaceans.

Rotifers are an entirely different story. Early on, I encountered some aquaculture folklore. For example, it is claimed that rotifers:

1. Die after 40 generations.
2. Should not be handled with screens.
3. Are difficult to separate from their faeces.
4. Cannot be stored in the refrigerator.
5. Very quickly metabolise and use up algae they have consumed.
6. Easily succumb to viral infestations.

Claims 1 to 4 have proved to be complete nonsense and it is beginning to look as though, suitably stored, their last algae diet may remain intact for days at least.

So far as 6 is concerned. Is there any need to expose them to virus?

My interest in zooplankton production stems from two things. One is that mollusc hatching is coming to the end of the road; we can produce far more than we can sell and, for various reasons, sales are declining. The other is that our algae production facilities are now so cheap to run that we believe we could supply significant quantities of zooplankton to the fish farming industry.

We have already crossed some bridges: Back to my 'folklore' again.

1. Rotifers reproduce about once per day. After 200 days I saw no signs whatever of deterioration in the stock, so gave up.
2. Using exactly the same procedures as we do for oyster larvae proved quite straightforward and at the same time assured against point 3 (about faeces).
3. Drained and stored in the fridge for 5 days left them all alive and ready to swim again within minutes of re-introduction to algae. The gut appeared to be full but that needs to be tested analytically before we can conclude anything about point 5.

There does seem to be a very real prospect of shipping rotifers to fish farms at any point of the globe if we can get the price right.

The rotifers can grow directly in algae from the flow-through system, which I would remind you contains only water that has been pasteurised. This means we can guarantee that it is free from any form of zooplankton or competing organisms. I would need to know more about the nature of the virus before commenting on that but there is a real possibility that it would not pass through the pasteuriser. If it did, there are other very simple pre-treatments that would eliminate it from the water before it reaches the algae culture.

There is a drawback. For the guarantees to stay in place the practice, much beloved of fish farmers for reasons of economy, of feeding rotifers on yeast, would have to go.

It is a fact that yeast is much cheaper than phytoplankton (Table 16.2). I hope in the discussion that follows to try to balance that equation.

Table 16.2. Yeast Cells Required to Produce 1.5×10^9 Rotifers/Day.

Yeast		Algae
Cost of yeast	\$0	all inclusive \$100.00
+ Water treatment	\$50	
+ Labour	\$25	
+ Amortisation tanks	\$?	
+ Algae enrichment facility	\$?	
Crash/total Loss?		0 risk.
Contingency purchase from another farm can be \$10,000	0 risk.	
Viral infection?	0 risk??	

Notes:

1. Quality off-the-shelf algae substitutes are not available. If they were to come available they might cost as much as the real thing.
2. If you are going to spend \$1,000,000 on a fish farm, why not include 10% for a really reliable algae unit?

RESEARCH PRIORITIES

1. The need to establish the optimum diet for zooplankton used in aquaculture. But what species? (including types more readily captured and ingested by zooplankton); how grown? light limited? nutrient limited? which commensal bacteria?
2. We need chemical profiles that enhance the zooplankton to effectively reduce problems such as albinism in flat fish and susceptibility to disease.
3. Food storage. There is a perceived need to store algae. Vast amounts of money have already been spent on this and research continues. Why is this? It's easier to reach down a tin of beans from the shelf than to make a fresh salad — we never deep-freeze lettuces.

There simply may be no cheap substitute for the real thing. Would it not be better to consolidate research on maximising production of top quality algae from naturally available resources? My company has already gone a long way down that road.