Algae: A Triple Solution To Aquaculture Industry Challenges

By Jose Sanchez Piña

VP of QA & Services, OriginOil Inc.

OriginOil EWS Technologies

Electro Water Separation (EWS) is a water treatment system that applies electromagnetic pulses to a water media in order to perform functions such as ŀmmonia removal, ƙƛƭƭƛƴƎ ƻŦ ōacteria, rotifers and other microorganisms, harvestƛƴƎ microalgae and chemical ŦǊŜŜ ƻƛƭ ǊŜƳƻǾŀƭ.

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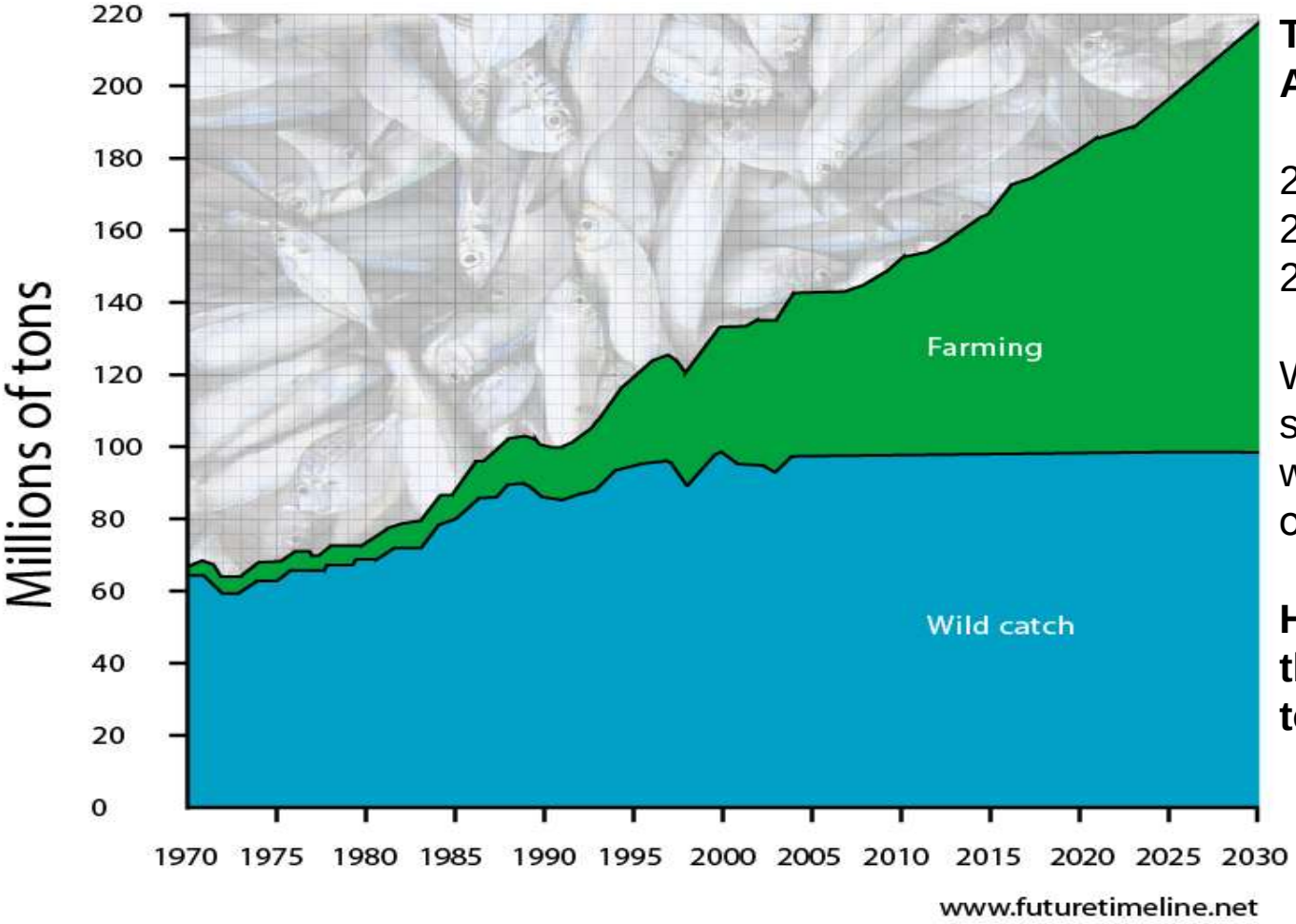
9 ² { ! ǉǳŀ Q60 π Ammonia & Bacteria wŜƳƻǾŀƭ 9 ² { Algae ! сл π ! ƭƎŀŜ Harvesting

What can OriginOil EWS do for Aquaculture Farmers?

- OriginOil EWS Aqua, equipped with an special alloy core, can **remove Ammonia from water**. This would decrease capital costs of Aquaculture (more animals per pond, and use the land in ammonia-reduction ponds)
- OriginOil EWS Aqua can **kill bacteria, virus and parasites** that attack fish/shrimp species and induce crashes in production (and for algae, this will provide you a clean water source).
- **OriginOil EWS Algae provides algae meal which is cheaper and more nutritious than conventional corn, soybean and fish meal-based balanced food**

What can OriginOil do for Aquaculture Farmers?

Fishmeal and Fishoil bottleneck



The Production of Aquafeed is:

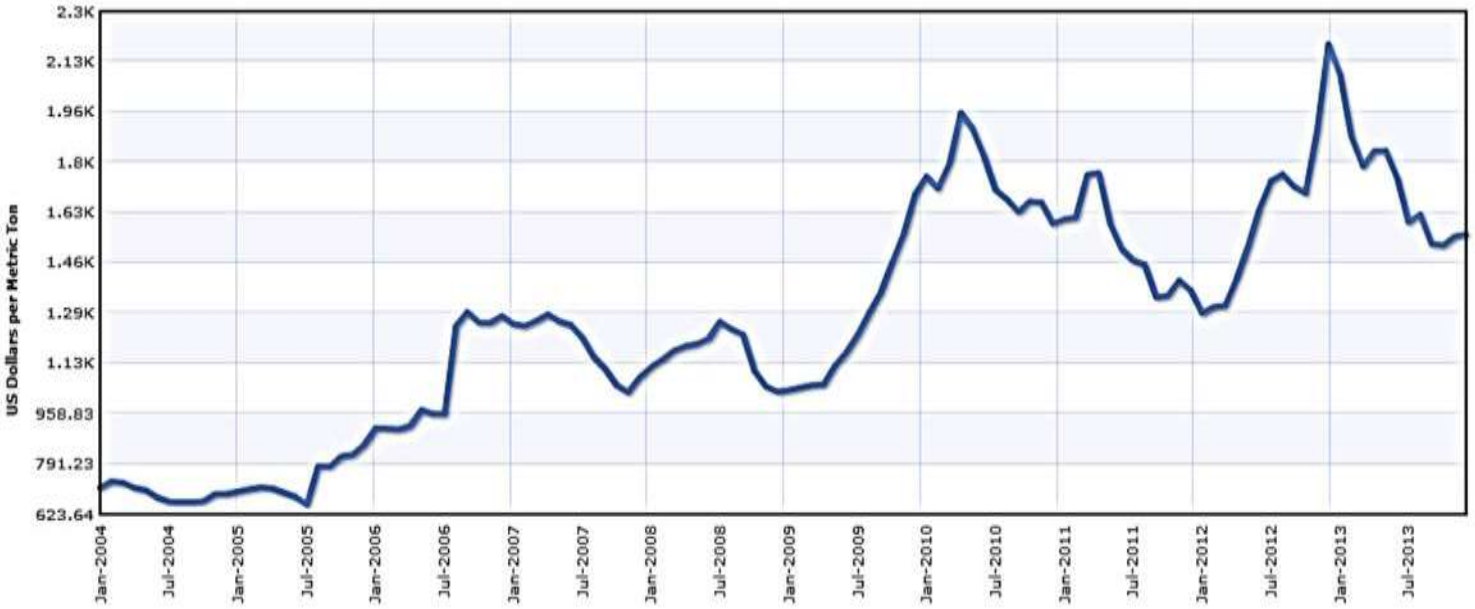
2005: 20 Million Tons
2010: 35 Million Tons
2015: 50 Million Tons

While wild catch has been steady at 90-95 MMT, and will stay like that from now on…

How it will be possible for the Aquaculture Industry to grow 6% annually?

What can OriginOil do for Aquaculture Farmers?

The current price of fishmeal is around $1600 US per metric ton. Algae paste could provide more competitive prices. The use of the appliance allow production costs below $800 US per ton for good and clean algae biomass to substitute fishmeal.



Fishmeal monthly price US $/Metric Ton Jan 2004-Dec 2013

Source: www.indexmundi.com

What can OriginOil do for Aquaculture Farmers?

Fish Meal from Captured Fish as Limiting Factor for Aquaculture Growth
Fisheries are the most important sources of feedstock for fishmeal. Only a small percentage of global fish production is actually channeled into the market for human consumption with the rest used for fish feed and animal feed. The proportion of fish processed into fish meal is not likely to grow due to the increasing demand for fish products in emerging economies like China.

Some doubts have been expressed that the world fish catch can be increased in a sustainable way, a figure around 100 million tons was being regarded as a reasonable maximum by the U.N. Food and Agriculture Organization in 1984 (for further reference, please check FAO's assessment in page 7 of FAO Technical Document 142, "The production of fish meal and oil" http://www.fao.org/docrep/003/X6899E/X6899E00.HTM), but this limit has been surpassed in the past 15 years, so world fisheries might decline soon.

What can OriginOil do for Aquaculture Farmers?

Algae has valuable proteins and fats

Microalgae Strain	Protein	Carbohydrates	Lipids
Scenedesmus obliquus	50-56	10-17	12-14
Scenedesmus quadricauda	47	-	1.9
Scenedesmus dimorphus	8-18	21-52	16-40
Chlamydomonas rheinhardii	48	17	21
Chlorella vulgaris	51-58	12-17	14-22
Chlorella pyrenoidosa	57	26	2
Spirogyra sp.	6-20	33-64	11-21
Dunaliella bioculata	49	4	8
Dunaliella salina	57	32	6
Euglena gracilis	39-61	14-18	14-20
Prymnesium parvum	28-45	25-33	22-38
Tetraselmis maculata	52	15	3
Porphyridium cruentum	28-39	40-57	9-14
Spirulina platensis	46-63	8-14	4--9
Spirulina maxima	60-71	13-16	6-7
Synechoccus sp.	63	15	11
Anabaena cylindrica	43-56	25-30	4-7

What can OriginOil do for Aquaculture Farmers?

Capital Cost Estimates of 1 Ha-microalgae producing pond (Conventional Pond Paradigms)

Capital Cost Items	Costs in US dollars
Site prep., grading, compaction	5000
Pond levees, hydraulic structures	3500
Mixing device (paddle wheels)	12000
Anti-infiltration Lining	20000
CO2 injection device	15500
Water and nutrient supply equip	5200
Buildings, roads, drainage	2500
Electrical wiring and distribution	2500
Subtotals of above	66200
Engin.& Contingencies(15% above)	9930
Total direct capital	76130
Land Costs	5000
Total Capital Investment	**81130**

$81130 financed for 10 years at 5% yr interest yields an annual payment of **$10326 dollars/yr**

Fixed Cost Estimates of 1 Ha-microalgae producing pond (Conventional Pond Paradigms)

Fixed Operational costs

Operational Cost Items	Costs in US dollars/yr
Labor (2 full time operators)	100000
Elect (5.16 KW , $0.1 dollars/Kwh)	4458
Maintenance (5% of Initial Capital)	4056
Management/Administration	10000
Cost of Sales	10000
Total Fixed Op Costs/yr	**128514**

Ops Cost Estimates of 1 Ha-microalgae producing pond (Conventional Pond Paradigms) 20 g/m2-Day or 72000 Kg Algae/year

Variable Ops costs

Operational Cost Items	Costs in US dollars/yr
CO2 ($27.65 Dollars/Ton) 2.0 Kg CO2/Kg Algae	3982
N- Urea (418 Dollars/Ton) 0.2 08 Kg Urea/Kg Algae	6260
P-DAP ($565 Dollars/Ton) 0.02 Kg DAP/Kg Algae	814
K- KCl (456 Dollars/Ton) 0.0057 Kg KCl/Kg Algae	187
Fe- FeSO4 (100 Dollars/Ton) 0.025 Kg /Kg Algae	180
Micronutrients (300 Dollars/Ton) 0.01 Kg/Kg Algae	216
Total Variable Op Costs/yr	**11639**

What can OriginOil do for Aquaculture Farmers

Capital Cost Estimates of 1 Ha-microalgae producing PBR (Close loop PBR Paradigms)

Capital Cost Items	Costs in US dollars
Site prep., grading, compaction	5000
Pond levees, hydraulic structures	3500
Hydraulic Hardware Control	50000
Programmable Control System	12500
Transparent bags/plumbing	75000
Anti-infiltration Lining	20000
CO2 injection device	15500
Water and nutrient supply equip	10400
Buildings, roads, drainage	2500
Electrical wiring and distribution	2500
Subtotals of above	196900
Engin.& Contingencies(15% above)	29535
Total direct capital	226435
Land Costs	5000
Total Capital Investment	**231435**

$ 231435 financed for 10 years at 5% yr interest yields an annual payment of **$29457 dollars/yr**

Fixed Cost Estimates of 1 Ha-microalgae producing PBR (Conventional Close Loop Paradigms)

Fixed Operational costs

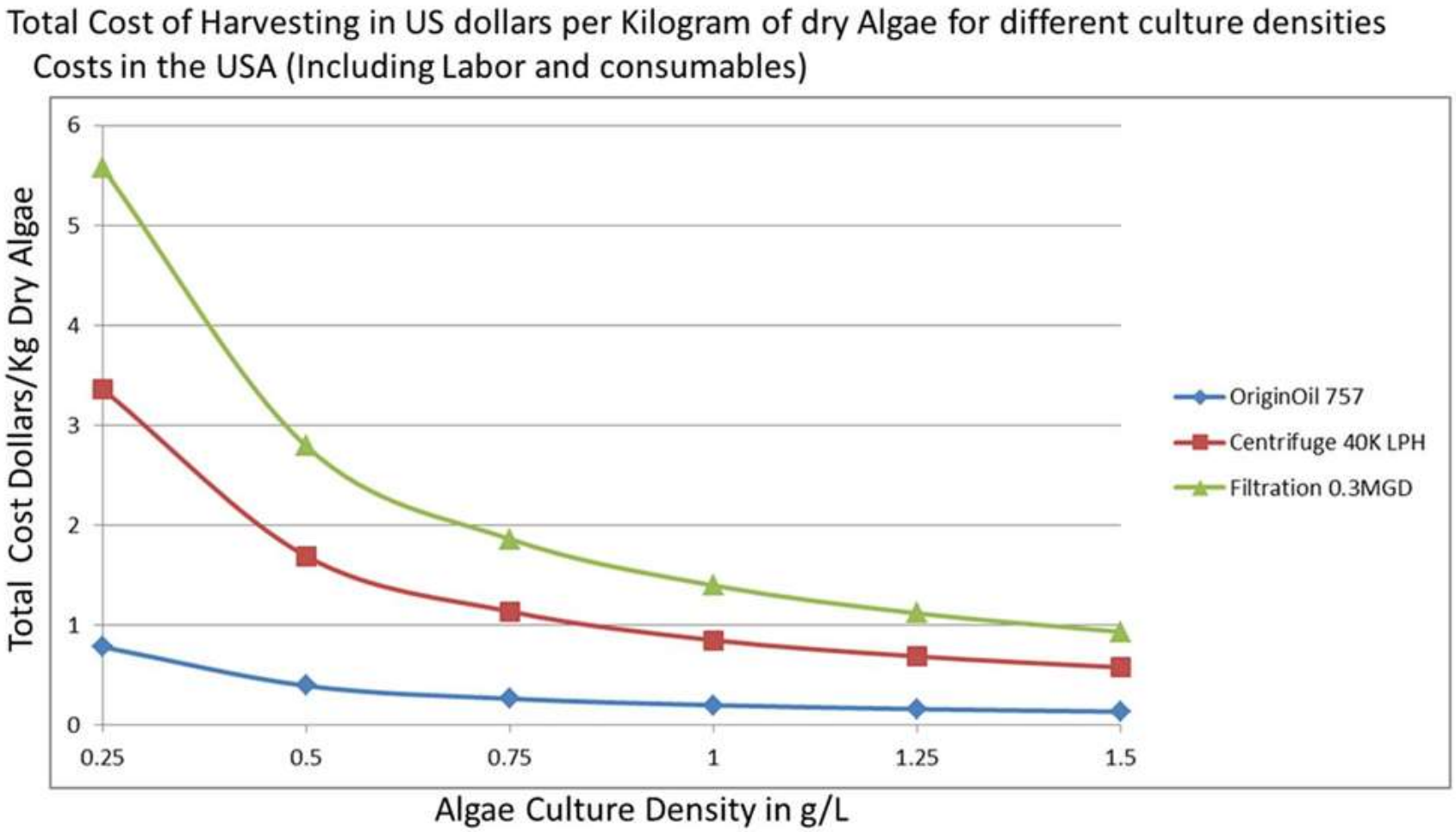
Operational Cost Items	Costs in US dollars/yr
Labor (1 full time operator)	50000
Elect (12.84 KW , $0.1 dollar/Kwh)	11094
Maintenance (3% of Initial Capital)	6493
Maintenance of Bags	20000
Management/Administration	10000
Cost of Sales	10000
Total Fixed Op Costs/yr	**107587**

Ops Cost Estimates of 1 Ha-microalgae producing PBR (Conventional Paradigms) 50 g/m2-Day or 180000 Kg Algae/year

Variable Ops costs

Operational Cost Items	Costs in US dollars/yr
CO2 ($27.65 Dollars/Ton) 2.0 Kg CO2/Kg Algae	9954
N- Urea (418 Dollars/Ton) 0.2 08 Kg Urea/Kg Algae	15650
P-DAP ($565 Dollars/Ton) 0.02 Kg DAP/Kg Algae	2034
K- KCl (456 Dollars/Ton) 0.0057 Kg KCl/Kg Algae	468
Fe- FeSO4 (100 Dollars/Ton) 0.025 Kg /Kg Algae	450
Micronutrients (300 Dollars/Ton) 0.01 Kg/Kg Algae	540
Total Variable Op Costs/yr	**29096**

What can OriginOil do for Aquaculture Farmers?



The OriginOil EWS Algae Harvesting Solution

- OriginOil's breakthrough algae harvesting system:
  - Lower capital and operating costs than *any* other de-watering process
  - High speed
  - Energy efficient
  - Chemical free
  - Completely scalable
  - Integrates upstream and down
  - Now a standardized, selling product line: **The EWS Algae™**

The EWS Algae

- Fully integrated algae harvester
  - Dewaters more thoroughly
  - Decontaminates to extend shelf life
- Model 12 delivers up to 12 LPM
  - In commercial production and sales
  - Entry-level, low-cost
  - Testing, R&D, process improvement
  - Will process 33% of daily harvest at 60,000-liter/day facility
  - Options: Decontamination, pre-harvest stimulation, capacity upgrade
  - Operator training, literature and support included

The EWS Algae A200

- Commercial algae harvester rated at 200 liters/minute
- Larger harvesters also available

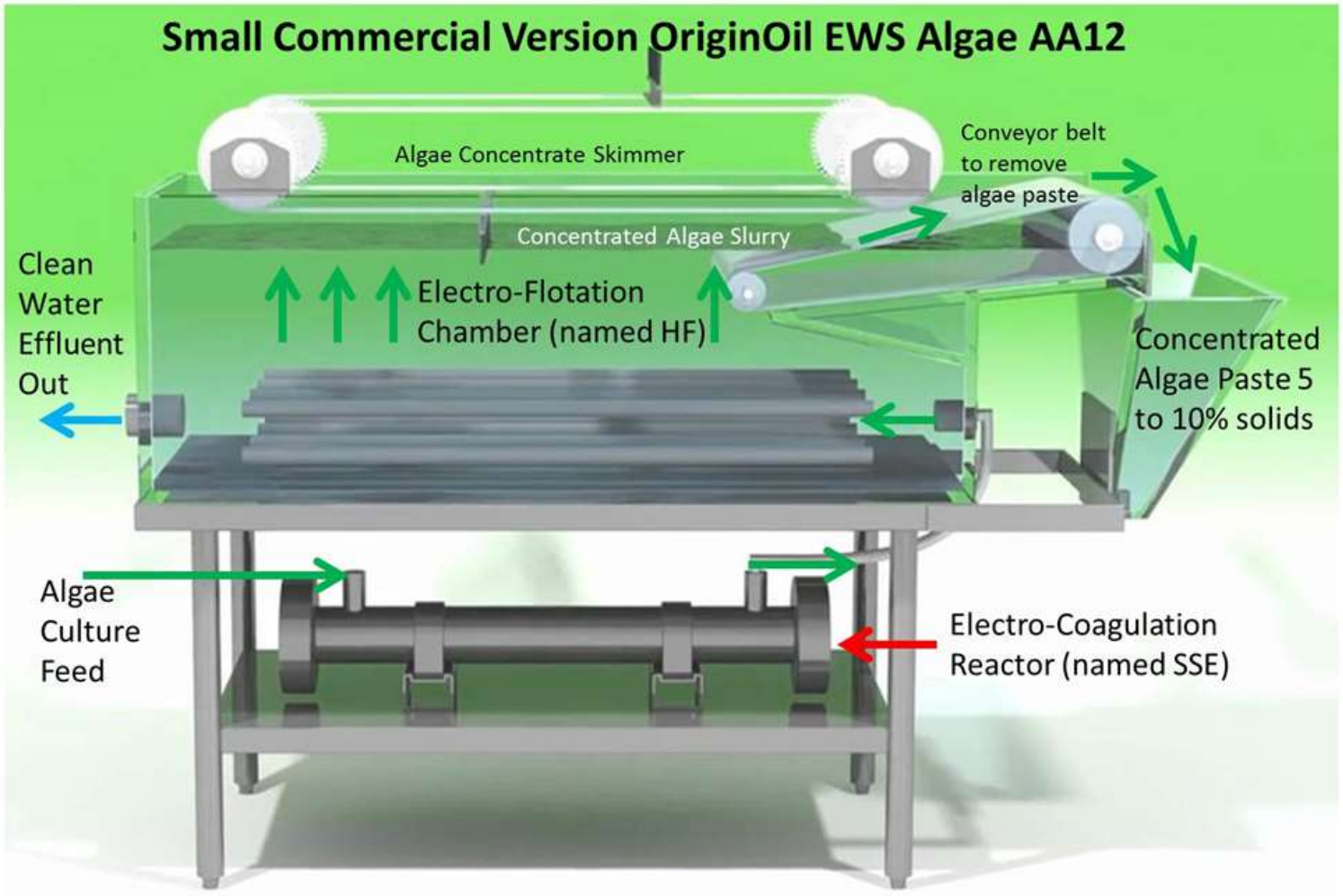
Versatile, Adaptable, Rugged

- Operates with all algae types and conditions: Any strain, salinity, degree of contamination, temperature, grown in autotrophic or heterotrophic mode

Harvesting algae grown in light

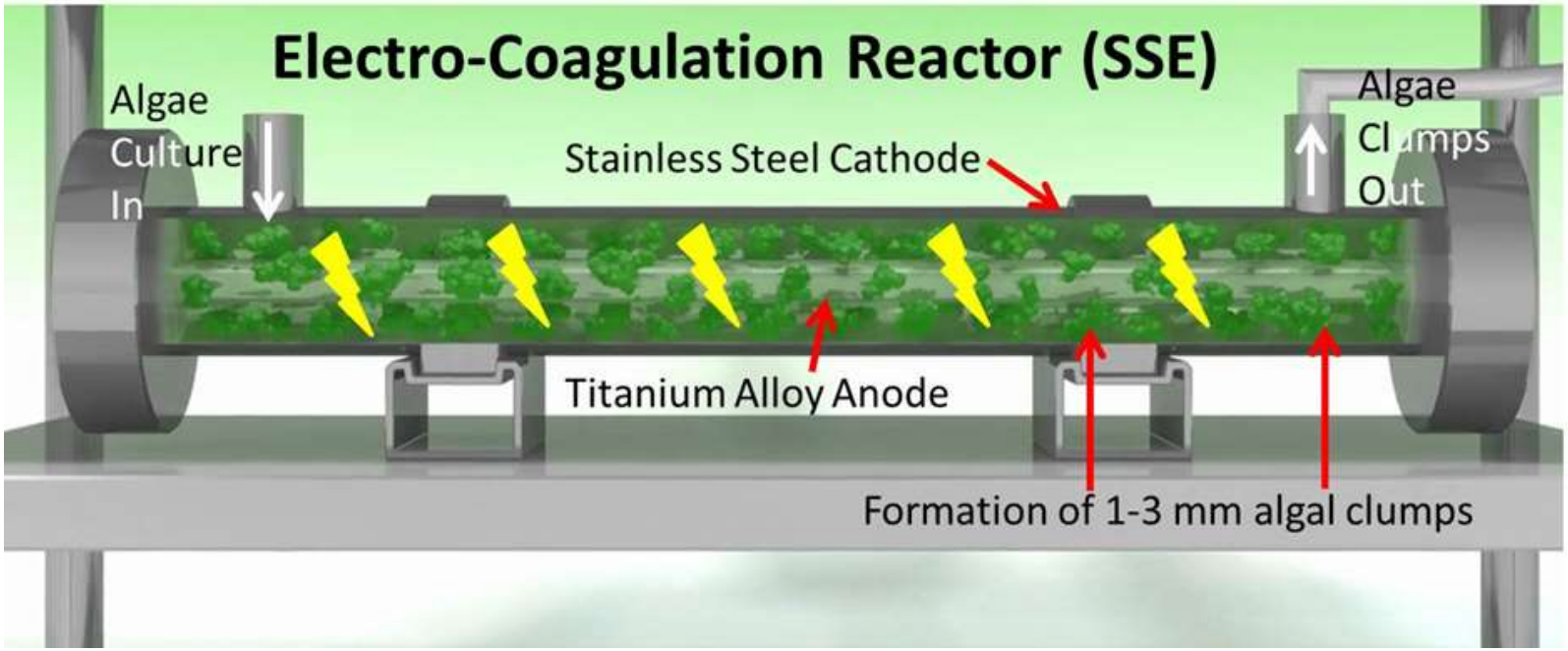
Harvesting algae grown in dark

Two-Stage Harvesting System



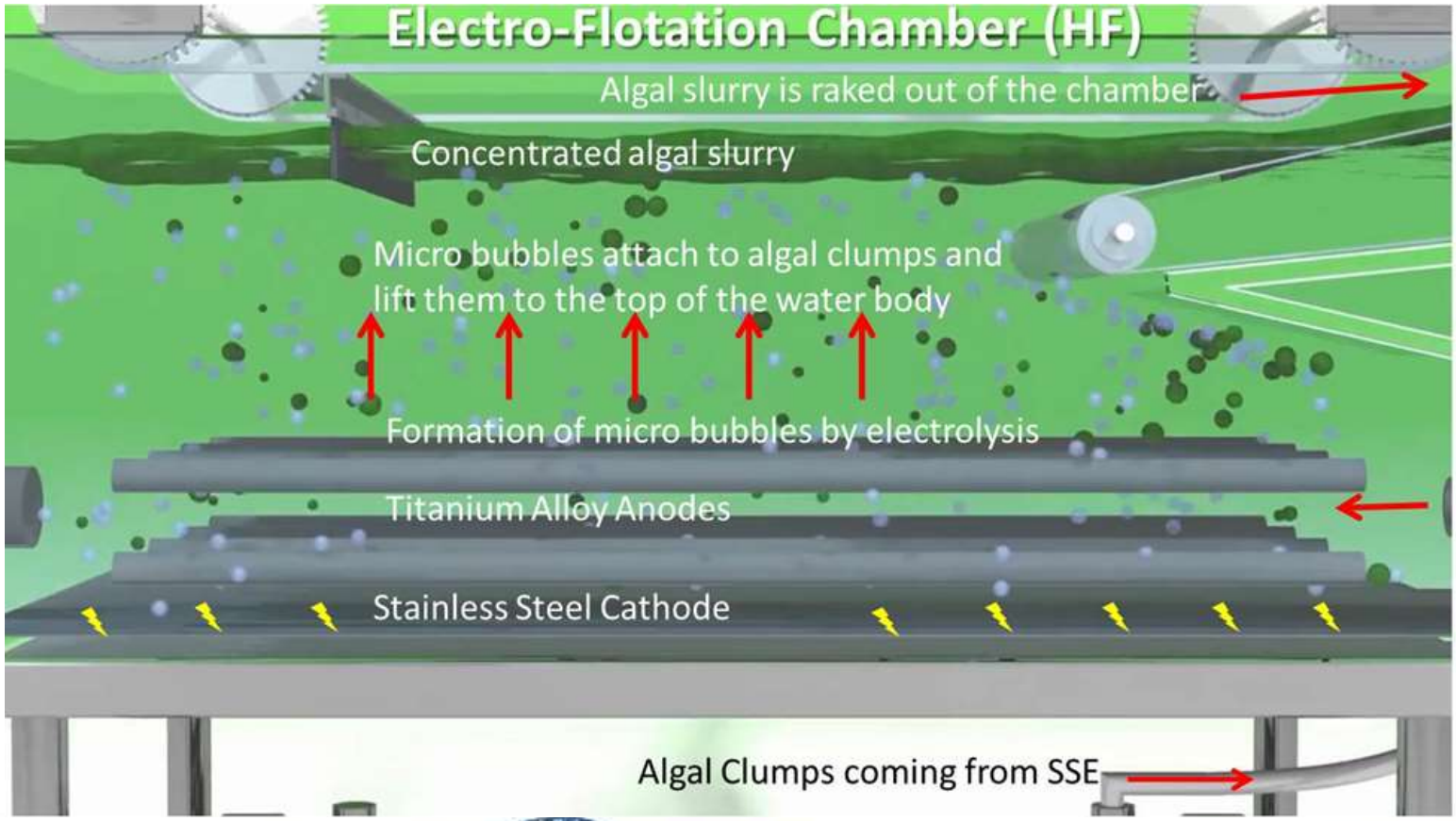
Two-Stage Harvesting System

1. **Single-Step Extraction™ (SSE)** neutralizes algae cells' electrical charge so algae clump together (flocculate). This is a "flocculation" type SSE, which does not damage the algae.

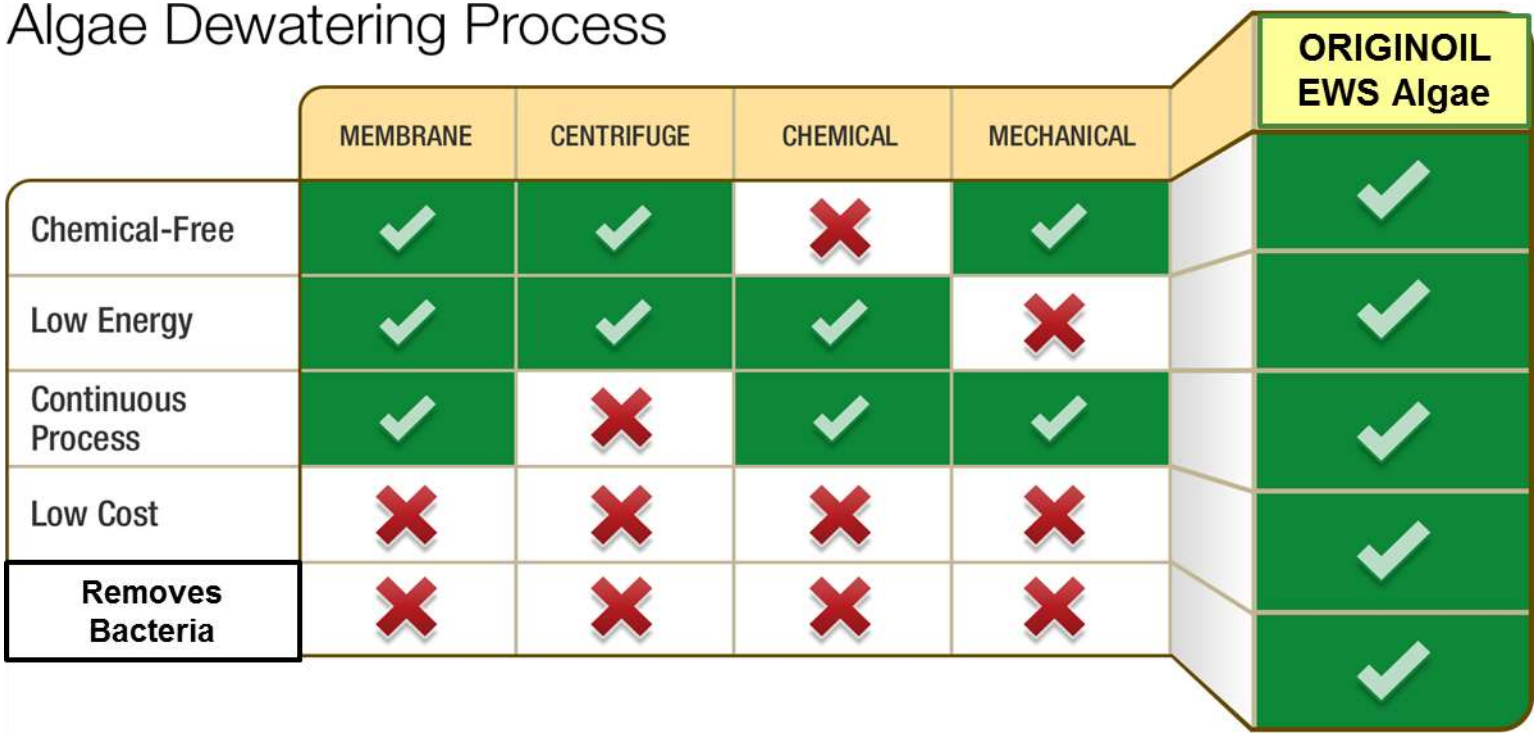


Two-Stage Harvesting System

2. Hydrogen Flotation™ creates a gas cloud of micro-bubbles pushing algae solids upwards for surface collection



EWS Algae VS other Harvesting Systems



Additional Advantages

- Clean Growth:
  - OriginOil's Algae Screen™ works on living algae to eliminate most bacteria, rotifers, ciliates and adverse algae
  - Decontaminated algae grows better, demonstrating improved yield at harvest*
  - Degree of improvement exceeds 50%, with potentials exceeding 80%

- Extended Shelf Life:
  - Normally, algae begins to rot after harvesting; short shelf-life complicates yield/ROI
  - EWS Algae decontamination delivers shelf-life up to one month**

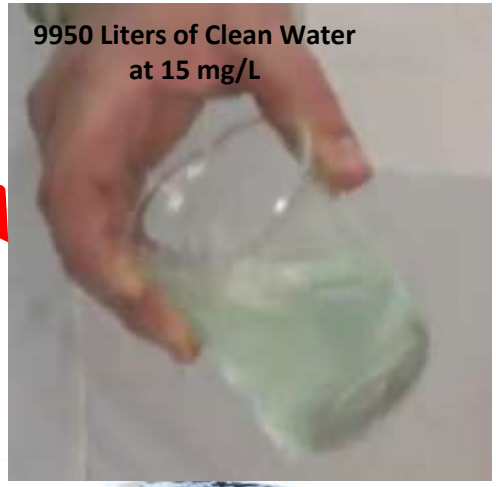
* Source: OriginOil Announces Breakthrough Innovation to Increase Algae Yield

** Source: OriginOil Internal Estimate (3rd party study in progress)

What can OriginOil do for Aquaculture Farmers?

When farming algae, if Contaminated… Harvest the problems away

90 to 99% Less Bacteria



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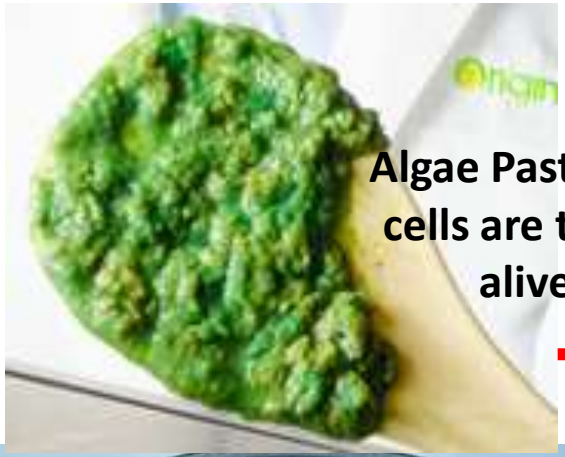
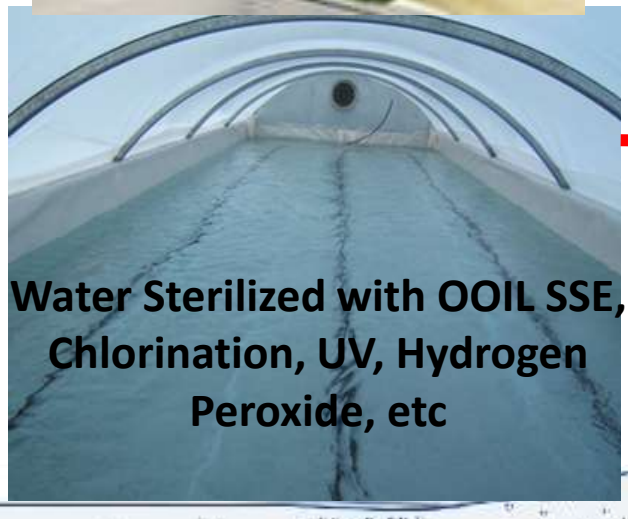


Algae Paste (The cells are totally alive)



Water Sterilized with OOIL SSE, Chlorination, UV, Hydrogen Peroxide, etc

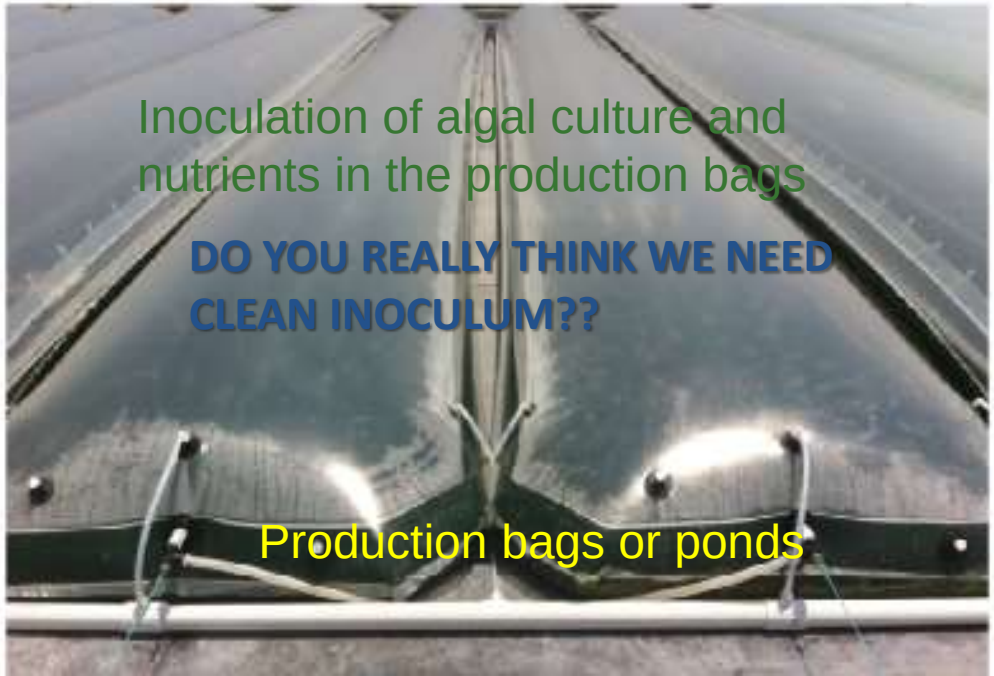
Back to Production in a few Hour$$$!!!

Algae Farmers Basic Need for Microbiological Control

From a few cells to Inoculation Carboys in the Culture Room

Culture intermediate scale up to 300 gallons in small photobioreactors

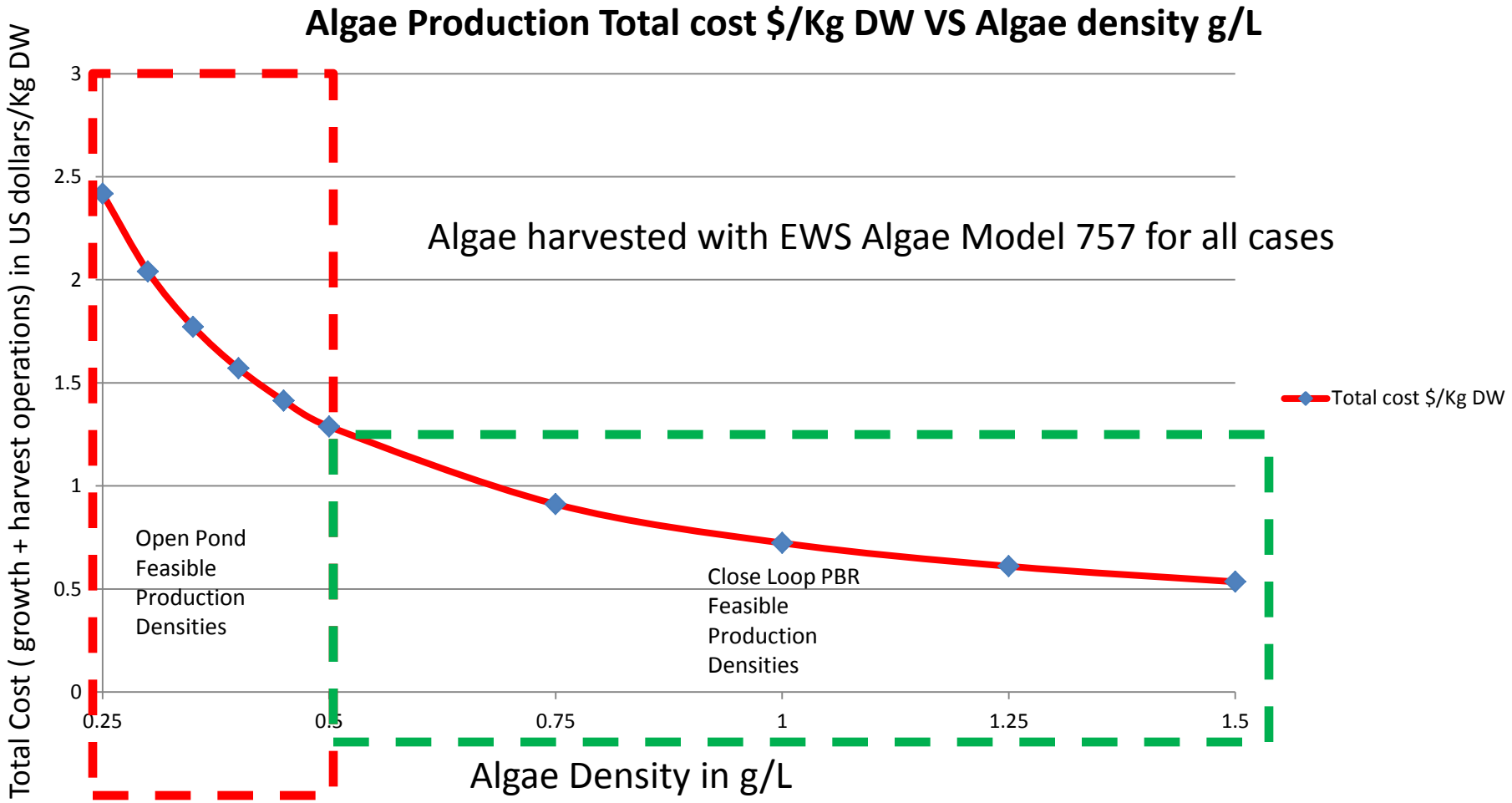
Culture production in large photobioreactors up to 15,000 gallon levels



Harvest Biomass without Bacteria

Increased Shelf Life/Quality

The larger Production Density, the least cost per Kg DW



Increased Digestibility for Aquatic Species

By choosing the algae with the highest protein content, the producer can reduce the overall pricing of its feed by mixing algae biomass with other feed sources such as soy or corn, while maintaining a digestibility that would assure maximum growth of their aquatic crop.

The digestibility determines the metabolic processes that induce growth in aquatic species for a given set physical and chemical conditions. The better the digestibility, the faster the growth.

The protein of species such as Chlorella and Scenedesmus contain aspartic acid, serine, alanine, leucine and glycine, which are more digestible to fish. For example, there are reports of 20% growth increase in Nile Tilapia, after substituting 50% of the fishmeal to Chlorella and/or Scenedesmus in the aquafeed formulation.

Better taste of Aquatic Species fed with Algae

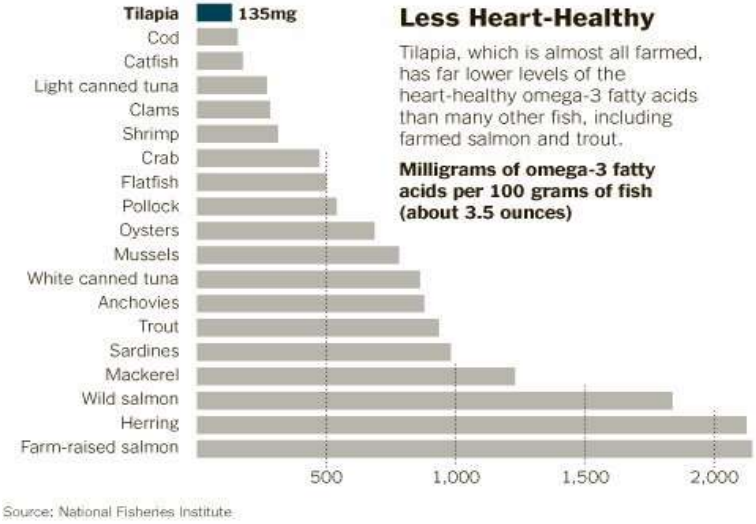
By substituting fishmeal with algae, the flesh of the aquatic species would present a “natural river taste” (for fresh water fish/shrimp) or “marine natural taste” (for saltwater species) equal to fish/shrimp caught in the wild, and not the slight “dog food” taste of fish and shrimp flesh fed with balanced food based on corn and soybeans, and fishmeal. This increases the value of aquaculture products in the food markets.

Better Health Benefits of Aquatic Species fed with Algae

From the Public Health's standpoint, fish fed from algae based feed would present a better ratio of Omega 3/Omega 6 oils in its flesh. Fish fed with Soy and Corn-based food would present low levels of Omega 3 with Eicosapenatoic fatty acids and relatively high levels of Omega 6 Arachidonic fatty acids.

The Omega 3 with Eicosapenatoic (EPA) fatty acid is a powerful anti-inflammatory that induces the reduction of the bad cholesterol and the formation of good cholesterol in the blood stream.
The Arachidonic acid induces inflammation and the formation of plaque in vein walls.

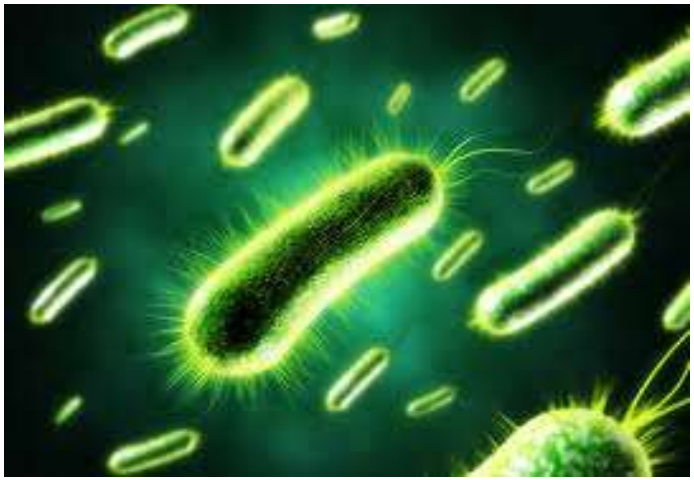
Algae is rich in Omega 3 with EPA, so fish fed with algae based food would present more health benefits than fish fed with soy and corn based foods.



Amount of Omega 3 fatty acids per 100 grams of fish for different species; Tilapia is almost 100% fed with soy and corn based foods, while carnivorous Salmon is fed mainly with fish (that ate algae).

Less bacterial outbreaks in Aquatic Species fed with algae harvested with EWS Algae

Algae harvested with EWS Algae™ would be devoid of 98 to 99% of the bacteria and other micro-organisms than algae harvested by other methods. Some of the epidemic outbreaks and sanitary emergencies in aquaculture farms occur due to contaminated food. Contaminated food from a centralized food formulation plant can affect several farms at a time, and induce outbreaks that can wipe out the production. By using independently farmed algae and by harvesting/cleaning it with the EWS Algae, it is possible to reduce the occurrence of epidemic outbreaks.



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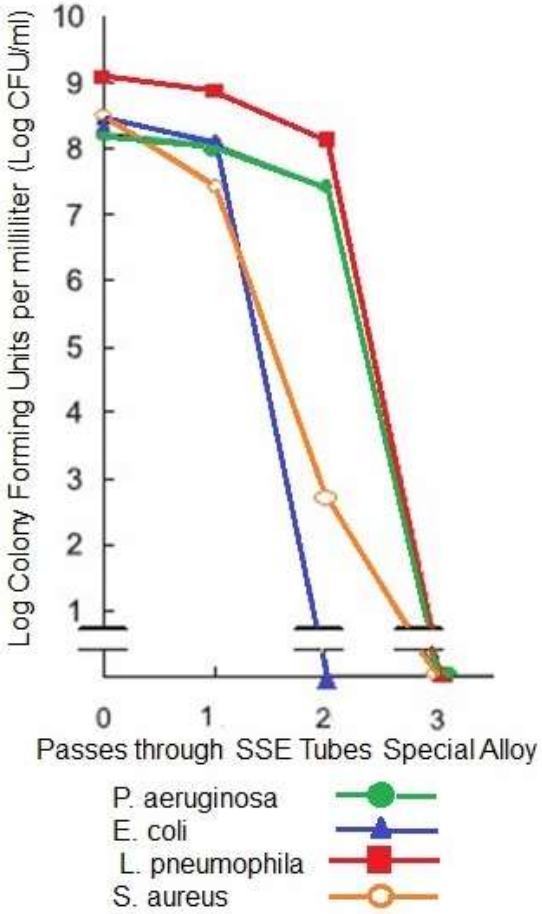
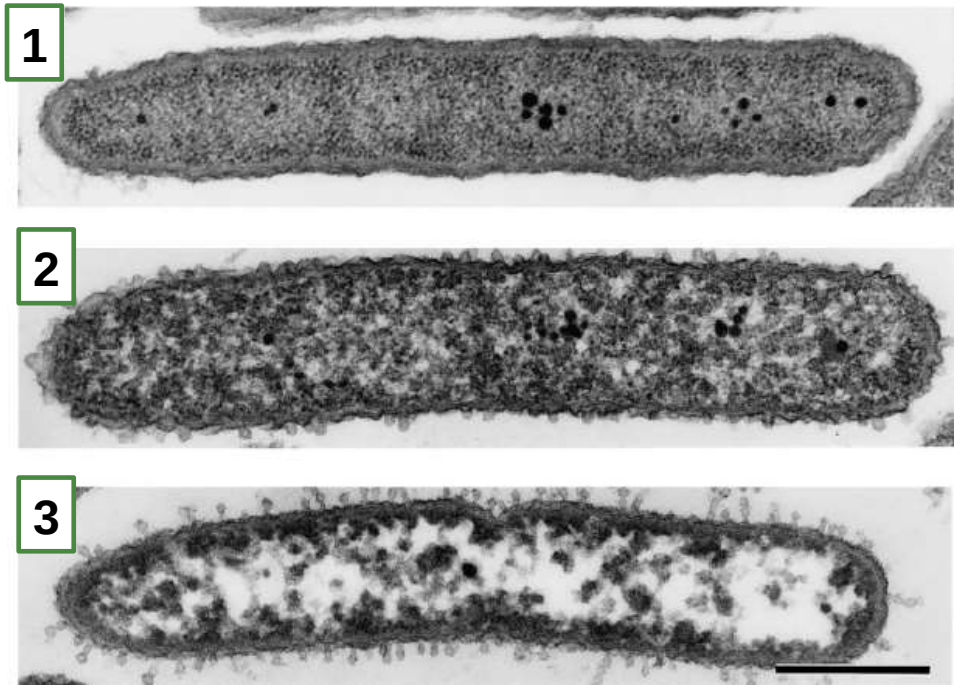




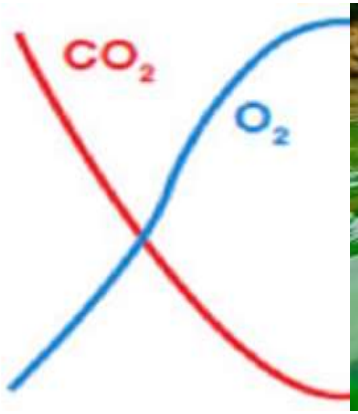
P. aeruginosa after several exposure steps (pay attention at cell walls)

Use of Algae in “Greenwater” Aquaculture

CO_2 affects the metabolic processes that induce growth in aquatic species.

CO_2 is expelled by the gills of the fish when they take oxygen from water and use it in their metabolic processes. Just like with any other animal, excessive concentrations of CO_2 in the media (in this case water), induce CO_2 poisoning, which stresses the fish and hampers growth. CO_2 poisoning is easy to observe when fish swim to the surface of the water and gasp for air.

When algae is added to the production pond or tank, the CO_2 exhaled by the fish is taken by the algae and emits oxygen back to the water. This reduces the stress of the fish and increases metabolic growth rates.



In Summary

- The Development of the Aquaculture Industry worldwide is constrained by the supply of fishmeal that is produced from fish caught in the wild.
- Farmed microalgae harvested with the EWS Algae™ is a perfect substitute for fishmeal.

- The use of farmed algae reduces the cost of the fishmeal, which can be as high as 35% of a farm's operating costs.

- The algae harvested using EWS Algae presents 99% less bacteria and other pathogens, reason for which it can aid in the prevention of adverse outbreaks and improve the sanitary management of a farm.

In Summary

- The use of algae as fish feed can help restore the taste equivalent to that of fish caught in the wild.

- Algae is rich in Omega 3 with EPA, so fish fed with algae based food would represent much better health benefits than fish fed with soy or corn based fishmeal.

- Algae management through the EWS Algae™ allows the safe use of algae to remove CO2 from ponds, which reduces stress and mortality and increases the growth rate of aquatic species.

- The use of Algae harvested with the EWS Algae™ will allow the use of more available and reliable feed, and this will free the Aquaculture Industry to keep growing and meet the current and future demands of decades to come.

Thanks

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