



WHITE PAPER

Use of Algae as Aquafeed to Improve Production in Aquaculture Operations

Background

For the first time in 2011, fish farming exceeded beef production worldwide and is growing five times faster. This increased demand, along with limits in wild fish catch has driven fishmeal prices up by almost 300% in the past decade. Fishmeal is a protein rich food obtained after processing fish caught in the wild, and is the base of any balanced formulation used in commercial aquaculture. By using EWS Algae™ and best practices in commercial Algae production systems, it is possible to produce an algae paste that substitutes fishmeal and decreases the overall price of feed.

Abstract

Fishmeal is the most important ingredient of balanced feed formulas used in Aquaculture. Fishmeal is brown flour obtained after cooking, pressing, drying and milling whole fish and food fish trimmings. Fishmeal provides an excellent source of highly digestible protein, beneficial fatty acids and essential vitamins and minerals. Fishmeal production has not risen recently because catch of wild fish has flattened. This has constrained the growth of Aquaculture as an industry worldwide.

A further problem in today's fish farms is the fact that fish food can cost up to 30-60% of the farm's operating costs and is predicted to keep on rising as worldwide fishmeal production has been flat for many years. There is a definite need for a new source of nutritious fish food.

Algae production systems used along OriginClear's Electro Water Separation™ (EWS) technology can solve this problem by producing algae paste as a cheaper more reliable substitute for fishmeal. EWS Algae harvests microalgae and removes 98 to 99% of bacteria, which increases the shelf life and quality of the feed. The use of EWS Algae, along with the best practices of algae farming will produce algae

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paste with a cost that ranges from \$400 to \$700 dollars/metric Ton, depending on location and production method. The current price of fishmeal is around \$1700 dollars/metric Ton. Given that fishmeal makes up for around two thirds of aquaculture costs, the substitution of fishmeal for algae would induce savings of about 40% in feeding costs. Algae would also be more widely available than fishmeal, which will overcome the “wild catch” constraint that has prevented the build up and development of Aquaculture facilities worldwide.

The EWS Aqua™ was specifically designed to clean contaminated fish farm pond water of ammonia, bacteria and pathogens in a continuous loop. EWS Aqua effluent water can also possibly fertilize algae for enhanced growth.

The use of algae as substitute of fishmeal provides additional benefits which include improvement on taste and consistency of flesh, increase in Omega 3 fatty acid content, and increase on the rate of growth of the aquatic species due to better digestibility. Another benefit of the use of EWS Algae for Aquaculture is that it allows farmers to have “green water ponds” where algae removes CO₂ from water, thus reducing the stress of the aquatic species being farmed and accelerating its growth rates.

Algae Inclusion into Aquaculture Feed

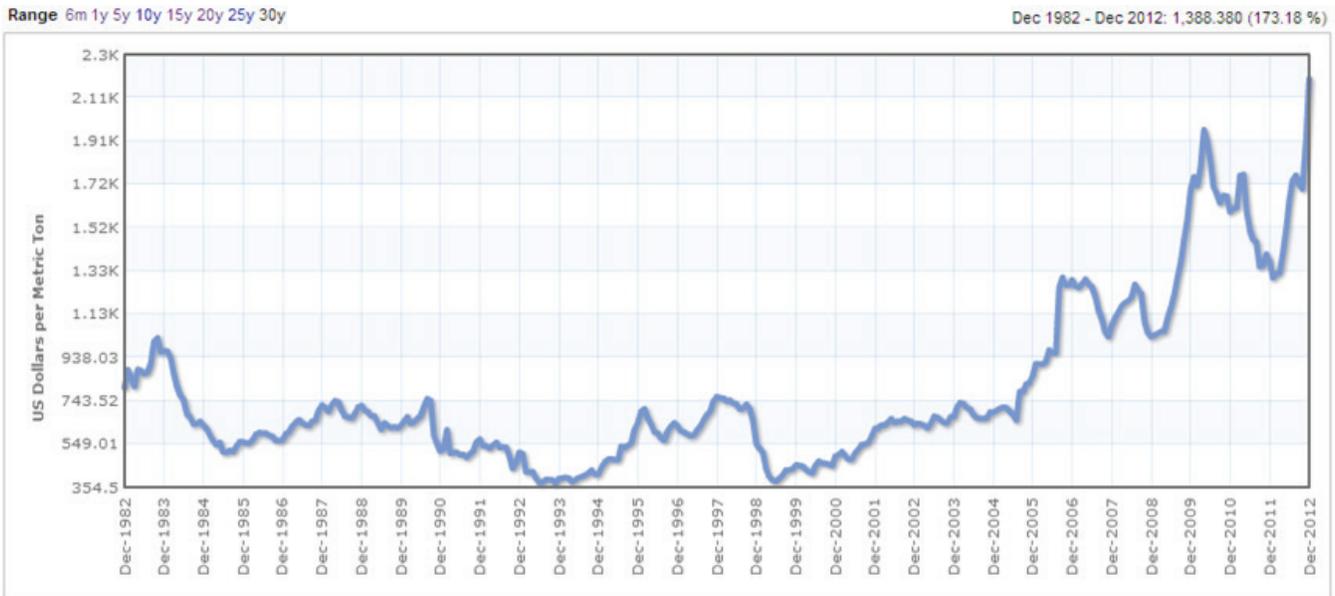
With aquaculture now providing more fish for human consumption than wild harvested fish, there is growing demand for fish feed. [A USDA lead scientist recently identified algae¹](#) as the potential solution to the challenge of a limited supply of fish feed that can be taken from the ocean and the limited supply of fishmeal ingredients.

Fishmeal is brown flour obtained after cooking, pressing, drying and milling whole fish and food fish trimmings. Fishmeal is usually produced from small, bony species that are difficult to process and preserve with conventional preserving methods. Fishmeal provides an excellent source of highly digestible protein, beneficial fatty acids and essential vitamins and minerals.

The growth in aquaculture has been based on availability of fishmeal or any other protein source. Fishmeal production has not increased throughout the last 20 years, so aquaculture development is constrained by this scarcity on fish meal, increasing the prices per ton from \$608 US Dollars/Ton in May of 2003 to about \$1700 dollars/Ton on May of 2013.

Usually about 30 to 50% of the feed given to aquatic species is fishmeal, and given that from 30 to 60% of the total cost of aquaculture operations is feed, this increase of price and volatility of fish meal, induces uncertainty in the economic feasibility of aquaculture operations.

1. <http://www.biodieselmagazine.com/articles/8153/usda-lead-scientist-explains-aquacultures-need-for-algae>



Monthly price per ton of fish meal from May 2003 to May 2013.

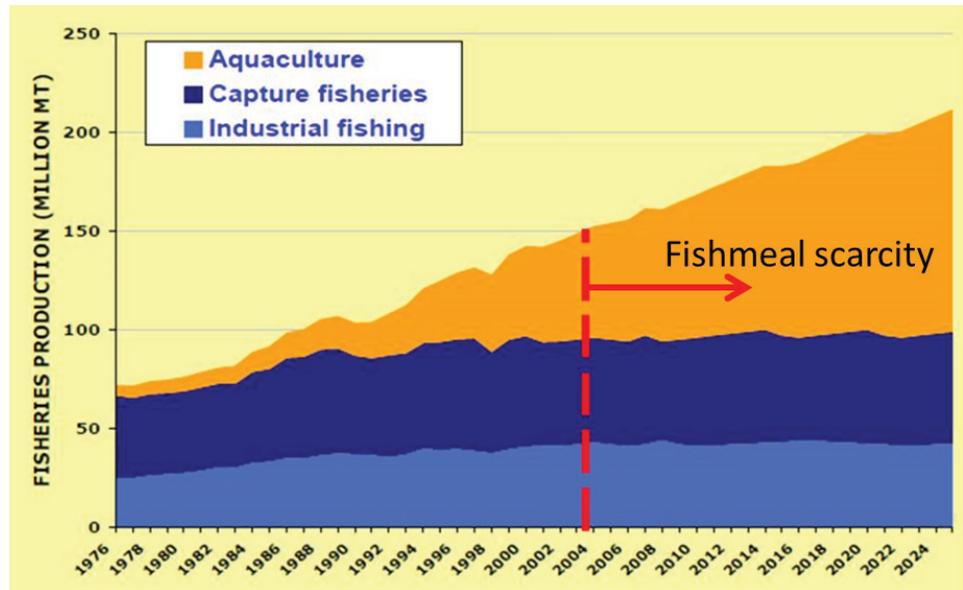
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Fish Meal from Captured Fish as Limiting Factor for Aquaculture Growth

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 fishmeal 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](#)"²), but this limit has been surpassed in the past 15 years, so world fisheries might decline soon.

As an example of this issue, in 2005 fish production estimates in the main fish exporting countries (Peru, Denmark, Chile, Iceland and Norway) declined by 12% (from 650,000 tons to 570,000 tons) and the fat content of captured fish declined as well (from 4 to 2 %). Total production metrics indicate a decrease in available fish density in the oceans and the decrease in the fat content might indicate that fish are being captured earlier during their lifetimes (fish don't have a chance to accumulate as much fat as before prior to their capture).



Historical and forecast of world fish catch and aquaculture production (indicating the initial date of scarcity of fish meal).

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Algae as Substitute of Fish Meal

Algae farmed in aquaculture sites can become a substitute for fishmeal. The cost of farming algae in most locations would be around \$400 to \$600 US per metric ton. If compared to the \$1,700 per ton that fishmeal costs, this shows a 60-70% savings in fishmeal costs. Algae is also a more reliable and less volatile source of protein, giving that its availability is not dependent on the fish captured. This provides the producers with a better control of their costs and the ability to forecast future investment or financial results due to the reduction of risk in aquaculture farming operations.

Algae also provide a way of controlling the nature and amount of nutrients given to aquatic species, the following table (next page) displays the nutritional characteristics of different algal strains:

By choosing the algae with the highest protein content, the producers 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, this is the reason for which there are anecdotal reports of increased production on aquaculture operations after switching from mostly corn/soybeans feed to algae feed.



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

Chemical composition of microalgae expressed on dry matter basis (%).



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Three Main Commercial Advantages of Algae

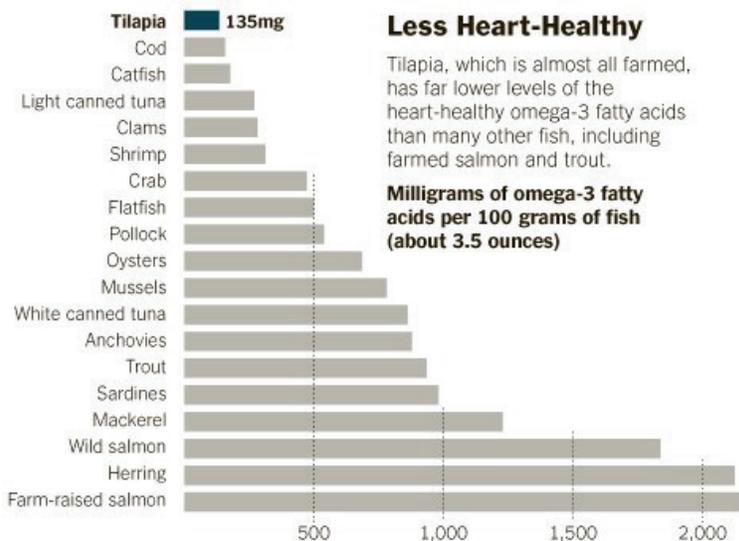
Other than reducing the volatility on feed prices, there are three other main commercial advantages of feeding algae to aquaculture species.

First Advantage

The first one is that the flesh will have 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 associated with fish and shrimp flesh fed with Purina (or any other balanced food based on corn and soybeans). This increases the value of aquaculture products in the food markets.

Second Advantage

The second and most important from the Public Health’s standpoint is that fish fed from algae based food 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.



Source: National Fisheries Institute

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).



The third is that 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.

Third Advantage

The third is that 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 EWS Algae, it is possible to reduce the occurrence of epidemic outbreaks.

Use of Algae in “Green Water” Aquaculture

CO₂ affects the metabolic processes that induce growth in aquatic species. CO₂ 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 CO₂ in the media (in this case water), induce CO₂ poisoning, which stresses the fish and hampers growth. CO₂ 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 CO₂ 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. The use of green water systems provides the additional advantage that it provides food for some herbivorous filtering species (such as rotifers-copepods-artemia systems or tilapia or oysters).

The use of successful “green water” CO₂ control in aquaculture systems for carnivorous species has been difficult to achieve, given that if the algal density increases over a threshold (because is not being consumed), it dies and takes the oxygen out of the water during its decay. In order to prevent algae density from reaching this threshold, aquaculture producers are required to do frequent water changes to take the algae away or harvest the algae with costly methods.

With the use of EWS Algae, it is possible to have an effective control of algal densities to maximize the benefits of a green water production system.

According to the [Food and Agricultural Organization of the United Nations](#),³ total global aquaculture production in 2008 amounted to a value of US\$106 billion. With 46% of the fish food supply for humans coming from aquaculture, there is growing need for fish feed.

Algae is starting to meet this need. The advantages of algae feeding to aquaculture species includes [increased growth](#)⁴ increased health benefits and improved taste, as the seafood would present a taste that is equal to fish and shrimp caught in the wild, thus increasing the value of aquaculture products in food markets.



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EWS Algae can multiply the benefits of algae cultivation for aquaculture producers, making the system a very compelling value proposition with an attractive ROI. It has the potential to make algae cultivation widely adopted and coupled with a [\\$106 billion dollar aquaculture industry that already exists.](#)⁵

Conclusions

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 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 total 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 management of a farm.

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 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 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.

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References

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