VACUUM AIRLIFT

SUSTAINABLE RAS DESIGN USING A VAL™

A Case Study in Sustainable Recirculating Aquaculture System Design using a Vacuum AirLift™

Situation

The intensified rearing conditions present in Recirculating Aquaculture Systems (RAS) present numerous challenges to the fish farmer. Management of water quality becomes paramount in the high density rearing conditions. The fish rapidly deplete the O_2 supply while producing CO_2 and solid waste. These actions quickly create an adverse environment if not properly addressed.

Requirements

The essential elements of RAS water management are circulation, clarification, biofiltration, degassing, and aeration. These elements provide an environment conducive to the health and growth of the fish by removing unwanted fine particulates, dissolved solids and waste gases produced by the fish while replenishing the O_2 consumed in respiration by the fish. Due to the competitive market created by wild caught fish, the water management system must have low acquisition and operating costs while providing simple and reliable operation.

Traditional RAS

The major components of the typical water reuse system are 1) the rearing tank for raising the organisms, 2) a mechanical filter for removing settled and suspended solids, 3) a biological filter for oxidation / reduction of total nitrogen, 4) UV or ozone disinfection to control bacteria and other pathogens, 5) a gas stripper for reducing CO_2 and N_2, 6) a pump for recirculating the treated water, 7) aeration / O_2 injection to restore depleted oxygen levels and 8) a skimmer for removing large / floating particulates.

There are several challenges / limitations with traditional systems:

Removal of suspended solids below 40 µm is difficult in traditional approaches such as drum, screen or sand filters which are not effective due to pore size versus pumping cost limitations. Fixed screens or rotating microscreens are limited in their effectiveness below 40 µm due to poor flow capacity leading to higher pumping costs and increased cleaning frequency. Sand filters are likewise limited by high head loss and the need for frequent maintenance.

UV or ozone disinfection is expensive due to the energy costs associated with generating UV or ozone.

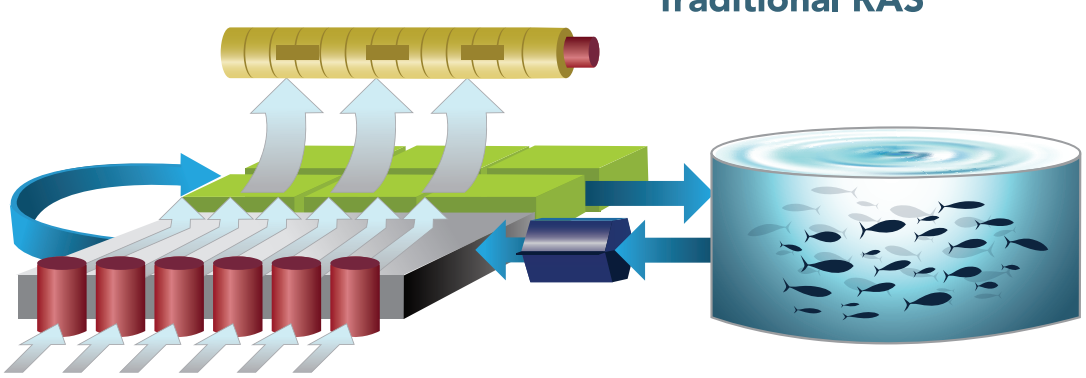
Stripping of undesirable gases, CO_2, N_2, etc. consumes energy and requires significant floor space to house the stripping chamber. In addition, the gases are frequently released within the building housing the RAS causing increased heating, ventilation and air conditioning (HVAC) costs.

Each of these challenges requires a specialized piece of equipment that 1) increases capital equipment costs, 2) requires additional floorspace thereby limiting production capacity and 3) increases operating costs due to additional energy consumption and increased maintenance.

Our Solution, the VAL™ Based RAS

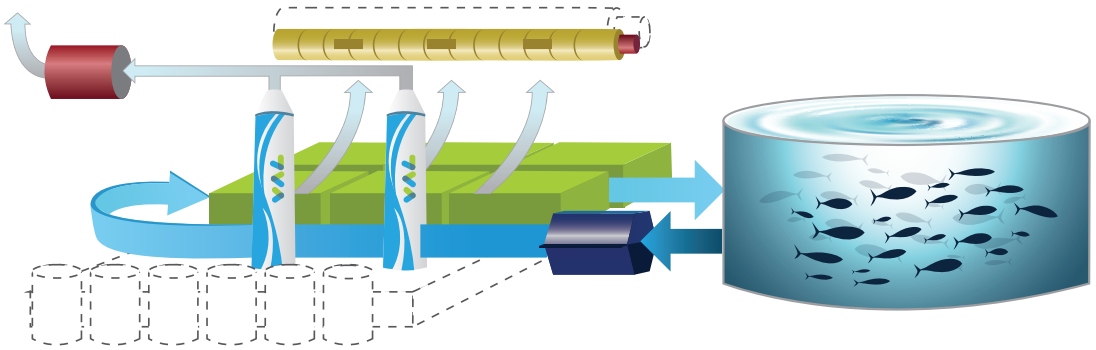
The Vacuum AirLift™ (VAL™) provides a multi-functional solution to RAS water treatment and management. The VAL™ is a patented technology that provides water circulation, gas exchange and particulate extraction in a simple, reliable and energy efficient device. The VAL™ continuously extracts fine particulates and pathogens through foam fractionation that contaminate fin fish rearing water. If left untreated this contamination leads to off flavor, biosecurity issues and risk of human illness or death. In addition, the VAL™ extracts CO_2, N_2, H_2S and other undesirable dissolved gases while replenishing the O_2 consumed in the rearing and denitrification processes.

Traditional RAS



Mechanical Filtration
Gas Management
Biological Filtration
Ventilation
Water Flow
Air Flow
Motors

VAL™ Based RAS



VAL:
Gas Management
+ Micro Filtration

Space And Equipment Saved

The VAL™ based system streamlines the design by providing the water circulation, suspended solids / pathogen removal, degassing and aeration in a single, simple, energy efficient device. The VAL's™ unique design allows it to capture waste gases and discharge them outside of the building greatly reducing HVAC costs. The illustrated example layouts provide a comparison of the equipment and floor space requirements for the water management system in a traditional and VAL™ based RAS.

The multifunctional performance capabilities of the VAL make it a uniquely powerful tool for sustainable RAS water management. A number of benefits accrue as a result of this performance:

1. Lower CAPEX due to reduced equipment cost
2. Lower OPEX due to reduced power consumption
3. Reduced equipment footprint
4. Increased reliability due to less complex equipment
5. Reduced or eliminated use of chemicals / consumables
6. Reduced maintenance due to equipment simplicity
7. Optimized, reduced or eliminated use of ozone
8. Optimized, reduced or eliminated use of UV
9. Increased margin due to lower overall costs

This case study review validates the VAL™ as a highly effective tool in addressing water circulation, particulate removal, degassing, aeration and other aquaculture water management and biosecurity issues.

VACUUM AIRLIFT™

RAS WATER MANAGEMENT USING A VAL™

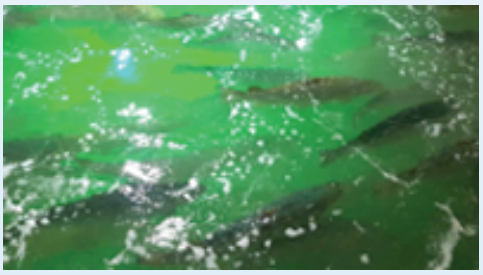
A Case Study Review of the Performance of a Vacuum AirLift™ in Recirculating Aquaculture Systems

Situation

The intensified rearing conditions present in Recirculating Aquaculture Systems (RAS) present numerous challenges to the fish farmer. Management of water quality becomes paramount in the high density rearing conditions. The fish rapidly deplete the O_2 supply while producing CO_2 and solid waste. These actions quickly create an adverse environment if not properly addressed.

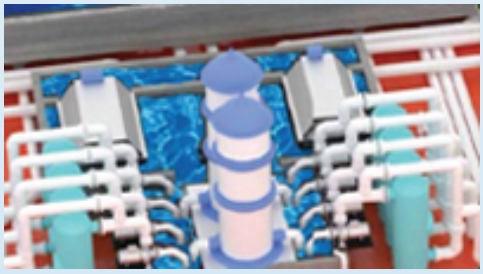
Requirements

The essential elements of RAS water management are circulation, clarification, biofiltration, degassing, and aeration. These elements provide an environment conducive to the health and growth of the fish by removing unwanted fine particulates, dissolved solids and waste gases produced by the fish while replenishing the O_2 consumed in respiration by the fish. Due to the competitive market created by wild caught fish, the water management system must have low acquisition and operating costs while providing simple and reliable operation.



Our Solution

The Vacuum AirLift™ (VAL™) provides a multi-functional solution to RAS water treatment and management. The VAL™ is a patented technology that provides gas exchange, particulate extraction and water circulation in a simple, reliable and energy efficient device. The VAL™ extracts CO_2, N_2, H_2S and other undesirable dissolved gases while replenishing the O_2 consumed in the rearing and denitrification processes. In addition, the VAL™ continuously extracts fine particulates and pathogens through foam fractionation that contaminate finfish rearing water. If left untreated this contamination leads to off flavor, biosecurity issues and risk of human illness or death.



The multifunctional performance capabilities of the VAL make it a uniquely powerful tool for sustainable RAS water management. A number of benefits accrue as a result of this performance:

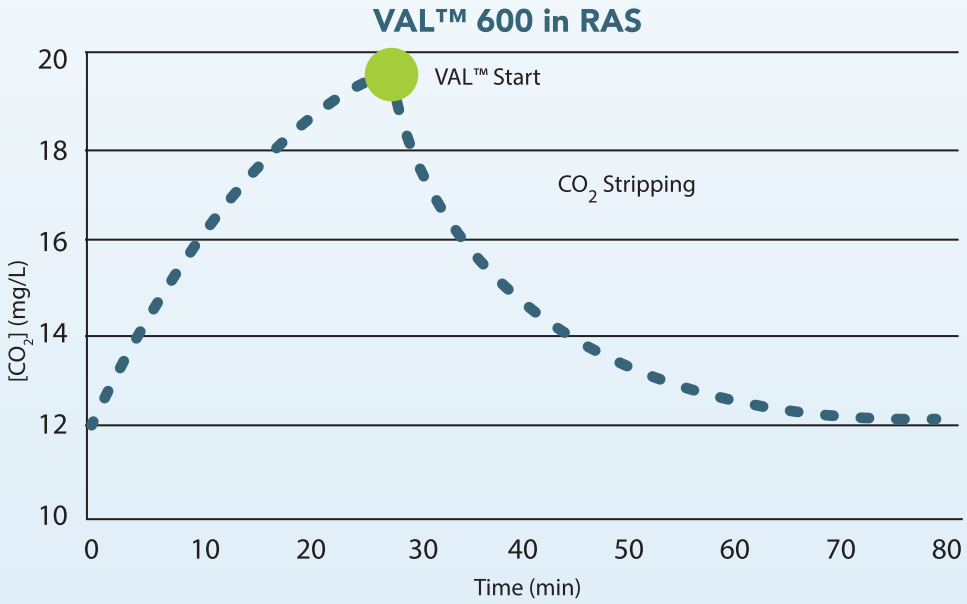
1. Lower CAPEX due to reduced equipment cost
2. Lower OPEX due to lower power consumption and low maintenance
3. Increased reliability and reduces risk due to simpler equipment
4. Decreased CO_2 and other undesirable dissolved gas levels due to VAL™ vacuum stripping
5. Increased O2 levels due to VAL™ aeration and reduced BOD
6. Faster growth and higher survival rate due to improved fish health
7. Increased biosecurity due to removal of pathogens and contaminants as well as more effective UV dosing
8. Increased margin due to superior product quality and higher biomass production

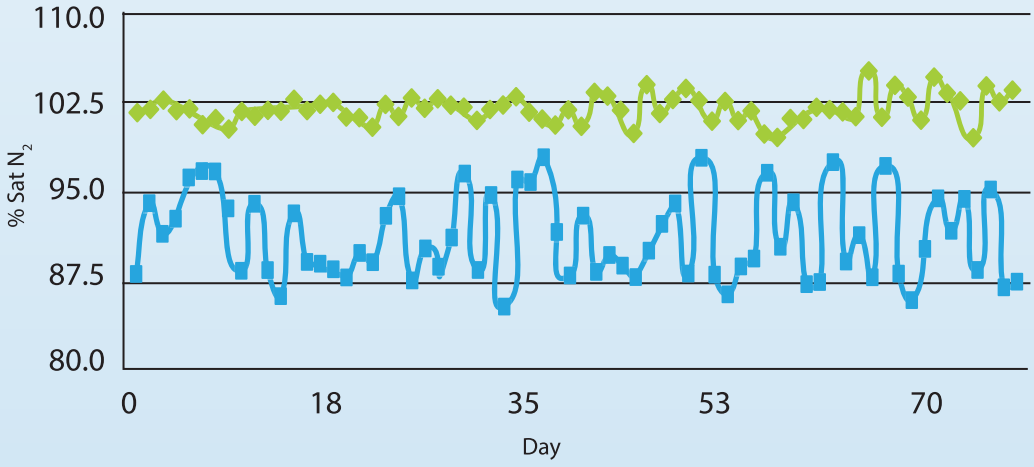
VACUUM AIRLIFT

Gas Stripping Capacity

The vacuum makes the VAL™ an efficient gas stripping device. The VAL™ has a Standard CO_2 Transfer Rate (SCTR) of around 11.2x10-5 $KgCO_2 m^{-3}s^{-1}$ providing a stripping efficiency around 15-20 $gCO_2/m^3/h$ of air injected. The combined effect of the vacuum and airlift microbubble injection results in low stripping energy, around 5-10Wh per m^3 of water treated.

Model	CO_2 Stripping Capacity
VAL™ 400	200 g to 600 g/h
VAL™ 600	500 g to 1.5 kg/h
VAL™ 900	1 kg to 3 kg/h
VAL™ 1200	2 kg to 6 kg/h
VAL™ 1400	2.5 kg to 7.5 kg/h
VAL™ 2000	6.5 kg to 20 kg/h



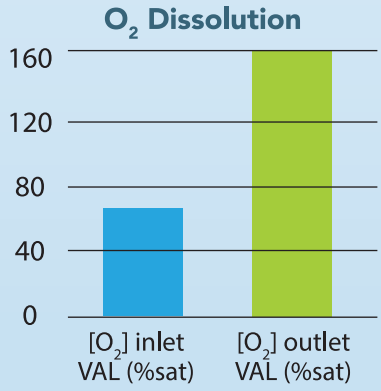


The VAL™ is also effective at stripping other problematic dissolved gases such as N_2 thereby preventing hyper saturation and its consequence, gas bubbling disease.

No VAL With VAL

Oxygen Dissolution Capacity

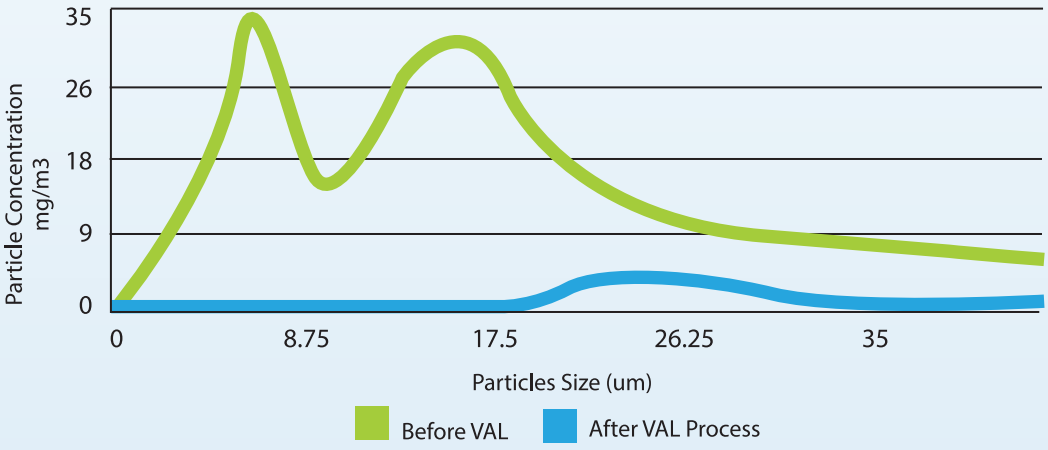
The high water retention time in the VAL™ outer column makes it an effective device for O_2 dissolution. The airlift circulation combined with the high water column created by the vacuum provides a mechanism for counter flow injection of O_2 in the down coming water. As a result O_2 dissolution efficiency of up to 98% is obtainable. This results in an O_2 dissolution as high 160% of saturation at the VAL™ outlet.



VACUUM AIRLIFT

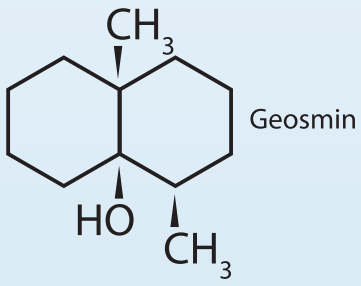
Foam Fractionation Capacity

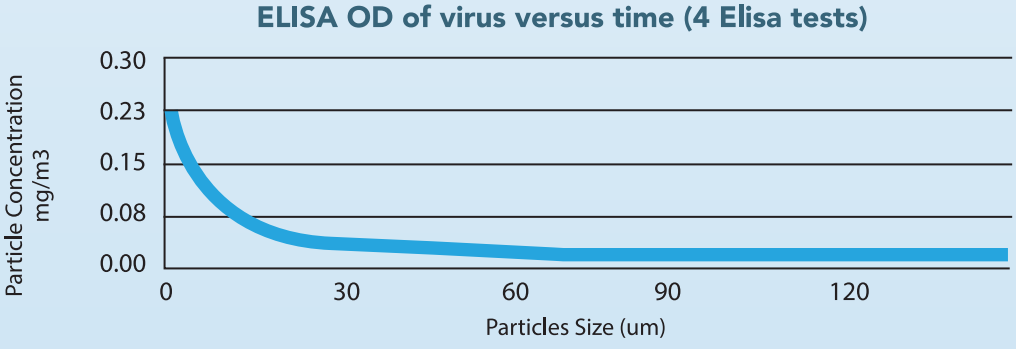
The microbubble airlift of the VAL™ provides foam fractionation capture of the fine particulates from the rearing water. This particulate laden foam is then removed by vacuum extraction making the VAL™ a highly efficient and effective particle skimming device. The VAL™ removes up to 99% of suspended particles less than 30 µm in size. As a result it provides a drastic increase in water clarity and UV transmittance while reducing the BOD load and clogging of the bio-filter. The VAL™ performs this particulate removal at low energy input. Depending on the application, energy input for particulate removal can range from 30 to 115 Wh per m^3 of water treated.

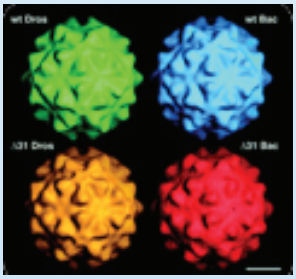


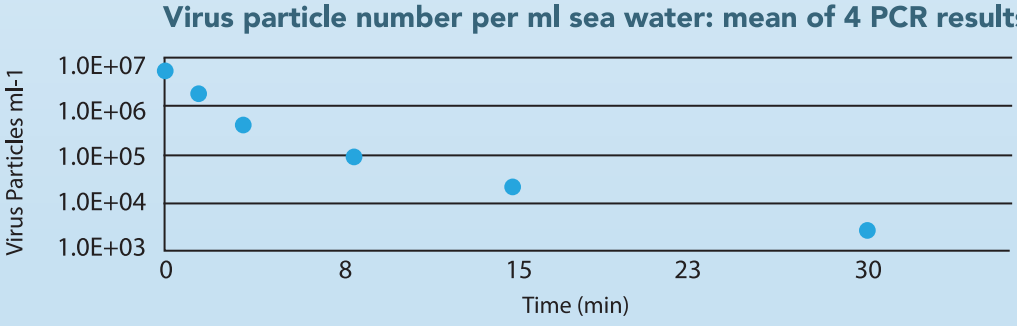
Biosecurity Effects

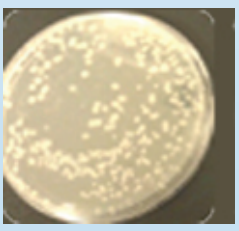
The unique foam fractionation capabilities of the VAL™ make it an effective tool for the enhancement of RAS biosecurity. The VAL™ can provide a 3 log reduction in virus concentration by foam fractionation and vacuum extraction. A 40% reduction in bacteria that produce off flavors such as Geosmin and MIB (DOM) has been achieved without the use of ozone. The VAL™ reduces the need for or enhances the effectiveness of ozone or UV treatment.

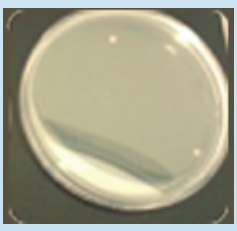










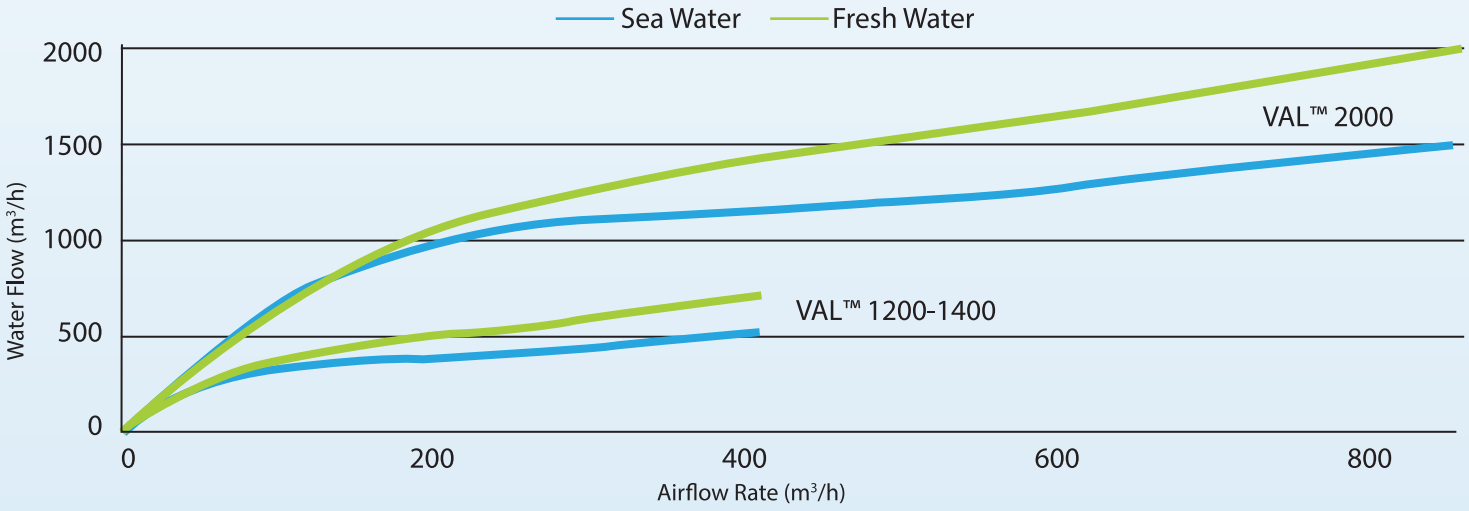


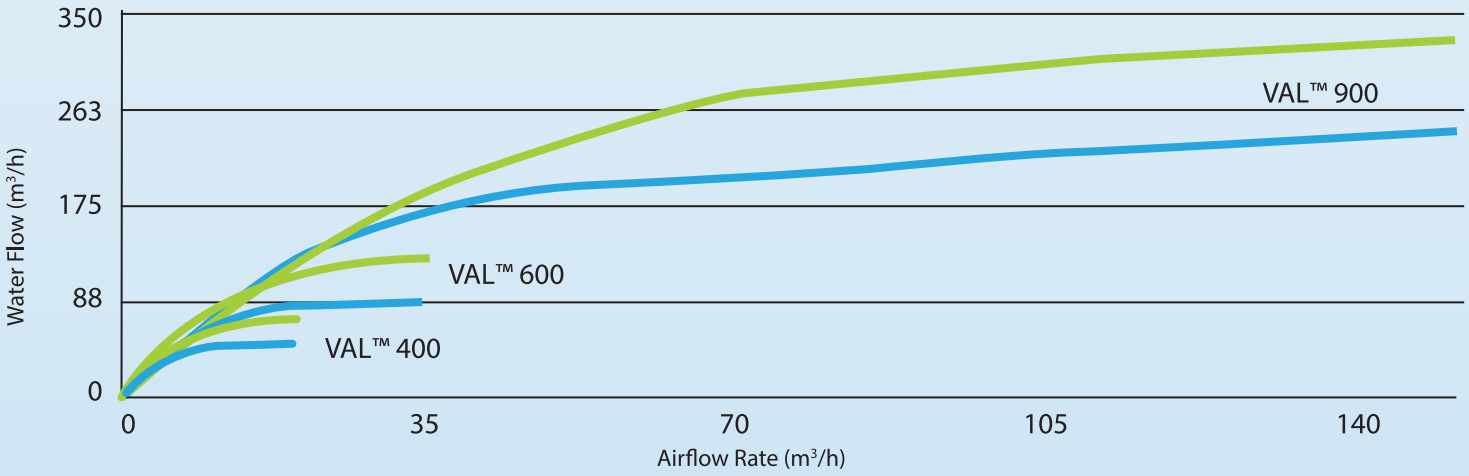
VACUUM AIRLIFT

Water Circulation Capacity

The airlift makes the VAL™ an effective water circulation device. Standard airlift water transport is around 3 times the water volume per volume of air injected. With low air injection it is possible to lift 3 to 10 times the volume of water per volume of air. Water circulation is accomplished with low pumping energy, around 3Wh per m^3 of water circulated.

Model	Water Flowrate (gpm)	Water Flowrate (m^3h^{-1})
VAL™ 400	220	50
VAL™ 600	600	135
VAL™ 900	1,300	300
VAL™ 1200	2,400	550
VAL™ 1400	3,000	680
VAL™ 2000	8,800	2,000





This case study review validates the VAL™ as a highly effective tool in addressing water circulation, particulate removal, degassing, aeration and other aquaculture water management and biosecurity issues.

VACUUM AIRLIFT

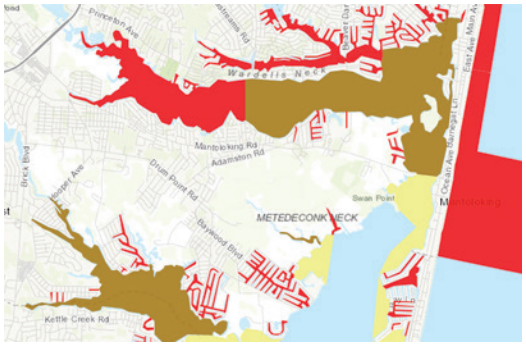
SHELLFISH PURIFICATION

A Case Study in Pathogen and Suspended Solids Removal

Situation

As filter feeders, bivalve molluscan shellfish concentrate contaminants from the water in which they are reared. When the shellfish are eaten these contaminants can pose a risk for humans, ranging from off-flavor to illnesss. The result is a biosecurity issue that must be addressed in the farming and harvesting of shellfish.

Contamination with bacteria and viruses in the growing area determines the processing that the shellfish need to undergo in order to comply with safe sanitary standards before consumption. The risk is considerably reduced by depuration treatment that purge the impurities from the shellfish.



Example : Barnegat Bay, NJ

Approved | Conditionally Approved | Restricted | Prohibited

Requirements

In the US, classification of harvesting areas is specified in regulations detailed in Chapter XV of the Model Ordinance of the National Shellfish Sanitation Program (NSSP; US FDA 2006).

The table below provides the US requirements.

US National Shellfish Sanitation Program Shellfish Harvesting Area Classification Criteria

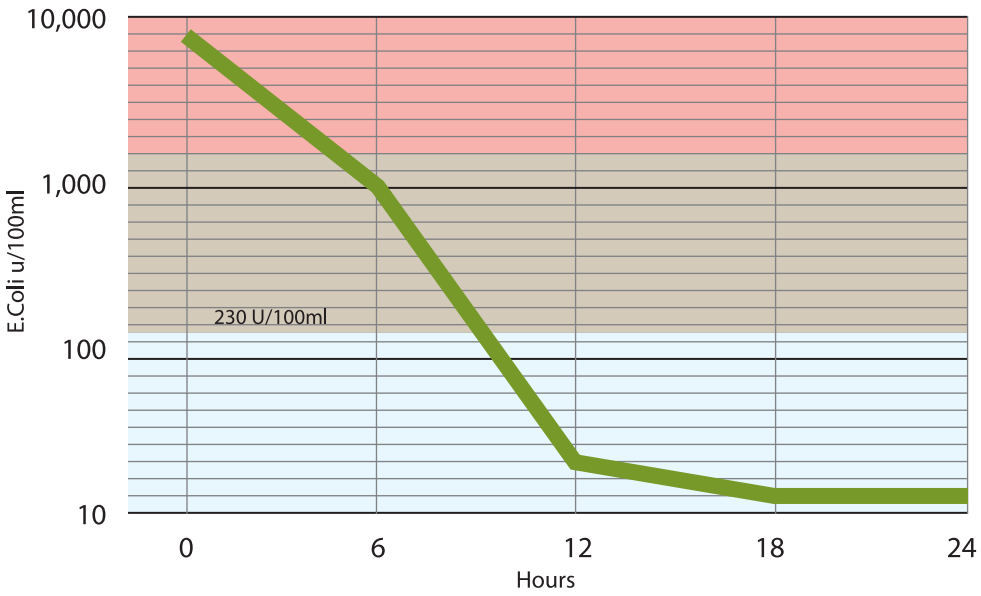
	Total coliforms (100 ml water)		Faecal coliforms (100 ml water)		
Classification	**Geometric Mean**	**90 % compliance**	**Geometric Mean**	**90 % compliance**	**Treatment required**
Approved Areas	≤70	≤230	≤14	≤43	None
Restricted Areas	≤700	≤2300	≤88	≤260	Purification or relaying in an approved area
Prohibited Areas	No sanitary survey or conditions for approved/restricted areas not met				Harvesting not permitted

Our Solution - The Vacuum AirLift™ (VAL™) is a simple and multi-functional, solution to water treatment

The patented VAL™ technology performs water circulation, gas exchange and particulate extraction in a reliable and energy efficient device.

The VAL™ extracts micro-particulates and pathogens that contaminate shellfish rearing water. If left untreated this contamination leads to off flavor, biosecurity issues and risk for adverse human health effects.

Oyster Depuration with the VAL™



100 gpm Oyster Depuration System

1300 gpm Oyster Depuration System

Results - Trial illustrating the VAL's™ effectiveness in shellfish purification.

This trial was conducted with a VAL600™, on a tank containing 1,300 gallons of sea water and live oysters. The test results were validated by the certified AQMC laboratory (COFRAC #1-1366).

Starting with an E. coli concentration 30 times the allowable limit, the VAL™ reduced the concentration to the 230 U/100ml threshold in approximately 9 hours. After an additional 9 hours the level had stabilized below 20 U/100ml, less than 1/10 the allowable limit. This test validates the VAL™ as a highly effective tool in addressing depuration and other aquaculture biosecurity issues. Our wide range of VAL™ models can treat 10 to 1,000 gpm of water, from purification tanks that contain 500 to 50,000 gal. of water with shellfish.

Please contact us to find the perfect VAL™ to fit your shellfish purification need.

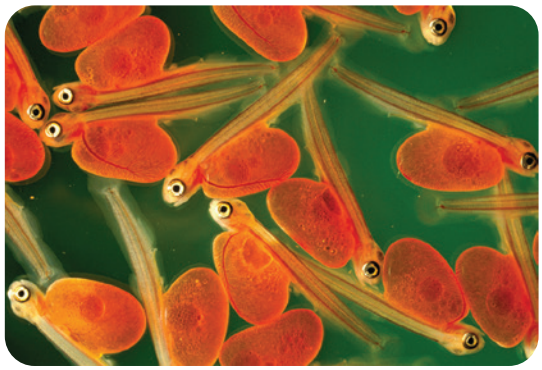
SEAREN www.searen.com | contact@searen.com | 513-400-3296

VACUUM AIRLIFT™

FISH HATCHERY GAS MANAGEMENT

A Case Study in Dissolved Gas Management

Situation



Maintaining high water quality is critical to the successful operation of a fish hatchery. To avoid pathogens, pollutants and other contaminants, water is generally sourced from deep wells. Unfortunately the high pressure in deep wells frequently leads to high levels or even supersaturation of undesirable dissolved gases. The presence of these gases can have detrimental effects on the delicate hatchlings. Supersaturated nitrogen can lead to Gas Bubble Disease which causes lesions, convulsions, blindness and death. High levels of carbon dioxide lead to reduced growth and high mortality. The toxicity of high levels of hydrogen sulfide also leads to high mortality. Other dissolved gases, such as VOCs, have a detrimiental effect on fish health. Conversely high levels of dissolved oxygen are required for the proper growth and health of the hatchlings. Poor dissolved gas management negatively impacts the return on investment by increasing the mortality rate and reducing the quality of the hatchlings.

Requirements

A western US fish hatchery utilizes mountain spring water at it's facility. The water contains high levels of nitrogen and carbon dioxide and less than optimal levels of dissolved oxygen. The hatchery investigated several approaches to address these issues. The cost / performance trade-off led to the selection of the Vacuum AirLift™ (VAL™) as their dissolved gas management solution.

Our Solution

The VAL™ provides a fully automatic, multi-functional solution to water treatment and management. The VAL™ utilizes a patented technology that provides water circulation, gas exchange and particulate extraction in a simple, reliable and energy efficient device.

The VAL™ continuously removes undesirable dissolved gases from hatchery water through fine bubble gas exchange and vacuum extraction. If left in the water stream these gases significantly decrease the survivability of the fish hatchlings and fingerlings. By injecting oxygen into the processed water stream, the dissolved oxygen level is raised to the level needed to ensure healthy and energetic fish fry.

VAL 600™ Treating Hatchery Source Water

Results

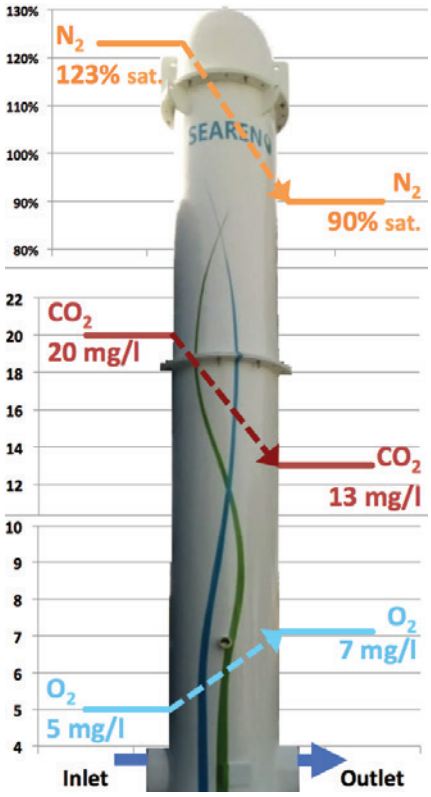
A Searen VAL 600™ was installed at the hatchery to treat the source water. The VAL™ processes the water at a flowrate of 450 gallons per minute. Pure oxygen is injected at the base of the VAL™ water at a flowrate of 4 liters per minute.

The hatchery measured dissolved nitrogen, carbon dioxide and oxygen levels across the VAL™. The test results are provided in the following table.

Parameter	Inlet	Outlet	Percent Change
Dissolved Nitrogen (% Saturation)	123	90.6	-26%
Dissolved Carbon Dioxide (ppm)	20	13	-35%
Dissolved Oxygen (mg/l)	5.25	7.06	+35%

The test results indicate that the VAL™ reduced the dissolved nitrogen and carbon dioxide by 26% and 35% respectively while the oxygen level was increased by 35%. These levels will have a dramatic effect on the surviveability and quality of the hatchery production. Those results are achieved in one pass, with the following specifications:

- The ratio of air to water is 1 to 4 (low thermal exchange)
- The stripped gasses are discharged outdoors (less indoor ventilation required)
- The energy consumption is as low as 10 watts per cubic meter of water treated
- As a result of the airlift, there is no head loss
- There is no packing media (no biofilm formation nor off-flavor produced by the system)
- There is no loss of efficiency over time
- One vacuum pump can serve multiple VAL™ units (yields higher energy efficiency and extremely low maintenance)



VAL 600™ single pass gas management performance

Model	Water Flowrate (gpm / m^3h^{-1})
VAL 400™	220 / 50
VAL 600™	600 / 135
VAL 900™	1,300 / 300
VAL 1200™	2,400 / 550
VAL 1400™	3,000 / 680
VAL 2000™	8,800 / 2,000

The airlift makes the VAL™ an efficient and effective water circulation device. Water circulation is accomplished with low pumping energy inherent in airlift operation. The VAL™ is available in a broad range of sizes allowing it to meet the water treatment requirements of any fish hatchery.

A number of benefits accrue as a result of this performance:

1. Lower CAPEX due to reduced equipment cost
2. Lower OPEX due to reduced power consumption
3. Increased reliability due to less complex equipment
4. Decreased carbon dioxide, nitrogen and other undesirable dissolved gas levels due to VAL™ vacuum extraction
5. Increased O_2 levels due to VAL™ aeration and direct oxygen injection
6. Faster growth and fewer mortalities due to improved fish health
7. Increased margin due to improved product quantity and quality

This installation validates the VAL™ as a highly effective tool in addressing dissolved gas management at hatcheries and other water treatment facilities.

VACUUM AIRLIFT™

FOAM FRACTIONATION

A Case Study in Suspended Solids Removal and UV Transmittance

Situation

The accumulation of particulate organic matter (POM) in recirculating aquaculture systems (RAS) has become an important issue with the intensification of finfish production. The presence and accumulation of POM (faeces, uneaten feed, parasites and bacterial flocs) in RAS can decrease water quality which leads to increased biological stress of the reared organisms. The accumulated POM leads to an increase in biological oxygen demand (BOD) for the system and the development of heterotrophic bacteria. These contaminants create fish management risks ranging from; 1) slow growth and higher mortality of the fish during rearing to 2) higher oxygen demand and higher biofilter load in the water management system to 3) off flavor and illness in humans when the fish are consumed. All of these factors negatively impact the return on investment by increasing the cost of raising the fish or reducing the marketability of the fish.

Barramundi Rearing Tank with Accumulated POM

Requirements

A US Barramundi farmer wishing to address these risks investigated a number of techniques for management and removal of fine particulates. Traditional approaches such as drum, screen or sand filters are not effective due to pore size versus pumping cost limitations. Fixed screens or rotating microscreens are limited in their effectiveness below 40 µm due to poor flow capacity leading to higher pumping costs and increased cleaning frequency. Sand filters are likewise limited by high head loss and the need for frequent maintenance. To address these issues RAS facilities are increasingly turning to foam fractionation or protein skimming as a means of POM removal.

Foam fractionation is a water treatment technology that can easily be added to water reuse systems to directly remove dissolved and fine suspended solids. The process of foam fractionation, also known as floatation, protein skimmming or air stripping, consists of injecting fine air bubbles into the water being treated. Micron sized air bubbles attach to surface active particles and carry them to the free surface forming a concentrated layer of foam that is then removed. In rearing farms, foam fractionation allows removal of fine particles smaller than 40 µm giving rise to high quality water. The ability of these devices to extract microparticles makes them effective biosecurity tools as they extract bacteria, viruses, toxic microalgae and parasites.

Our Soution

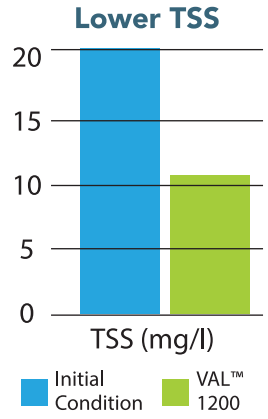
The Vacuum AirLift™ (VAL™) provides a multi-functional solution to water treatment and management. The VAL™ is a patented technology that provides water circulation, gas exchange and particulate extraction in a simple, reliable and energy efficient device. The VAL™ continuously extracts fine particulates and pathogens through foam fractionation that contaminate finfish rearing water. If left untreated this contamination leads to off flavor, biosecurity issues and risk of human illness or death. In addition, the VAL™ extracts CO_2, N_2, H_2S and other undesirable dissolved gases while replenishing the O_2 consumed in the rearing and denitrification processes.

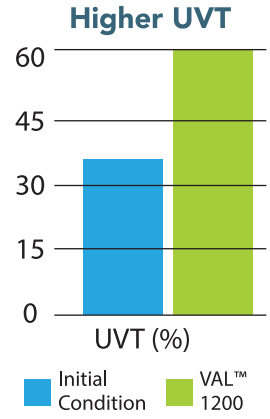
VAL™ Treating Rearing Tank Water

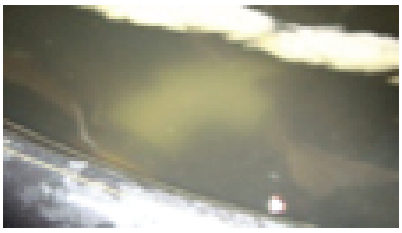
Results

A demonstration was conducted to illustrate the VAL's™ effectiveness in treating finfish rearing water. The demonstration was conducted using the VAL™ installed after the drum filter in Barramundi RAS. The system had a biomass of 12,000 lbs and a recirculation rate of 350 gpm. Total Suspended Solids (TSS), UltraViolet Transmittance (UVT) and Input Power were measured at the start of the demonstration and after stabilization. The test results are provided in the following table.

	Initial Conditions	VAL™ Model 1200
TSS (mg/l)	20	11
UVT (%)	37	59
Power (kW)	N/A	2.0







Low Clarity Before VAL™ Treatment

Improved Clarity After VAL™ Treatment

The test results indicate that the VAL™ reduced the TSS by 45%. As a result of the reduction in TSS the VAL™ increased the UVT by 22%.

A number of benefits accrue as a result of this performance:

1. Lower CAPEX due to reduced equipment cost
2. Lower OPEX due to reduced power consumption
3. Increased reliability due to less complex equipment
4. Decreased CO_2 and other undesirable dissolved gas levels due to VAL™ vacuum extraction
5. Increased O_2 levels due to VAL™ aeration and reduced BOD
6. Faster growth and fewer mortalities due to improved fish health
7. Increased biosecurity due to removal of pathogens and contaminants as well as more effective UV dosing
8. Increased margin due to improved product quantity and quality

This demonstration validates the VAL™ as a highly effective tool in addressing particulate removal and other aquaculture water management and biosecurity issues.