European Commission

AirX Report Summary

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Periodic Report Summary 2 - AIRX (Oxygenation by efficient air diffusion system for aquaculture farms (cages and earthen ponds))

Project Context and Objectives:
Background
Sea bass and sea bream aquaculture is an important source of income in many Mediterranean regions, especially in Greece, Turkey and Spain that are representing some 80% of the entire production volume. Over the last years, the total annual production of these species has levelled at 300,000 MT. Aquaculture in Greece is considered 'the 2nd most important key economic sector for the growth of Greek economy'. Other species, such as meagre and sharpsnout sea bream, are new promising candidates for so-called multi-species cultivation in Mediterranean fish farms.
Grow-out farming in the largest producing countries takes mainly place in floating sea cages, while some 15% of the total volume are produced in land-based pond systems in other countries, e.g. in Portugal and Italy. Sub-optimal dissolved oxygen (DO) concentration deficit is a potential problem both in cages and ponds, and the risk of harmful deficit is generally highest in late summer – early autumn at water temperature above 25 – 27 °C. These species seem to cope rather well to low DO (hypoxia) compared to cold-water species, but long-term tests with sea bass has demonstrated reduced appetite and growth at DO saturation below 80% even at a temperature as low as 22 °C. At increasing temperature in August - October, so-called early morning DO deficit, sometimes results in critical conditions (e.g. fish kill). A well-known contributing factor to such critical situations is the rising oxygen consumption in fish at increasing temperature. Reported problems with sub-optimal and even critical DO in Mediterranean fish farms was the basis for a performed project applying aeration in order to better control DO.

The AirX-project
A research project, both incorporating research institutions and commercial partners in Greece (Universities of Patras & Thessaly, Zervas-Kyriazis fish farm), Portugal (IPMA, Atlantik Fish, F.Ribero Lda.), Italy (RefaMed) and in Norway (OxyVision, TI, IRIS), has been carried out over the last two years. The project, AirX, was funded from the 7th Framework Programme of the European Union.

Among the main objectives are optimization of diffuser based aeration, mapping of DO deficit problems in commercial farms, and comparative tests of cost – benefit employing aeration technology (OxyVision) in ponds and cages. Additionally, the lacking knowledge of effects of DO deficit and fish density in sea bream culture has been compensated for by performed tests at IPMA.
Project Results:
Efficiency of diffusers
Numerous combinations of diffuser hoses with regard to structure/material, pre-treatment, puncture density, inner and outer hose combinations, etc. were tested in an experimental tank at OxyVision's lab. The decisive parameter, 'Standard aeration efficiency', SAE, was determined in all tests and the most efficient diffuser hose was selected for further in-field tests at the facilities in Greece and Portugal.
The best in test diffuser hose attained a SAE-value of 2.7 kg O2 transferred from air to water per KWh of electricity consumed. Compared to reported efficiencies of other types of commonly applied aerators in aquaculture (paddle wheels, propeller-aspirator-pumps) the achieved SAE-value was most promising. Not least, the efficiency was clearly higher than reported from other conducted diffuser tests in the 1980'ies.

Risk of DO deficit in sea cages
Aeration is common practice and considered vital in many land-based culture operations. Traditional sea cage culture, however, still relies on natural water exchange replacing oxygen consumed by the fish stock. In spite of episodic fish kills due to critical DO drops, there are few reports available describing such episodes in Mediterranean cage farms. As a part of the project, monitoring of DO and water exchange has been performed at one farm site in Greece. The oxygen conditions at this locality is primarily dependent on the rhythm of the tidal water, but the diurnal algal activity will also play a role. Especially at the turn of the tidal flow, the respiration of the fish stock may cause serious DO deficit in the stagnant water column in the cages, as demonstrated at 10-11 AM on 16 November. Improved DO control by aeration and thus stabilizing the concentration above 60% of saturation would be a significant attempt to optimize the conditions for the stock.

Diffuser based aeration tests in sea cages and earthen ponds
Surface aerators, such as paddle wheels and propeller-aspirator pumps, are commonly used aeration systems in earthen ponds. However, it is also possible to use diffuser based systems that inject fine gas bubbles, using blowers that supply air at low pressure. In large earthen ponds and fish cages, where oxygen has to be distributed over a large area, usage of submerged diffusers is advantageous because of the large interface between injected air and the water body as the fine air bubbles are slowly rising to the surface.

Several AirX prototypes have been developed as a result of continual improvements throughout the project period. The first technical tests were performed in canvas lined raceway tanks (Sardinia, Italy) in spring 2013. These tests were succeeded by aeration of earthen ponds at IPMA's research station (Algarve, Portugal) and of sea cages at a commercial farm (Greece) in summer and autumn 2013. The tests resulted in updated diffuser layouts for commercial-scale trials initiated during the summer 2014.

The earth ponds were stocked with both meagre and sea bream, whilst the sea cages were stocked with either sea bass, or sea bream. Parameters, such as DO and total gas pressure (TGP) in the water column, and pond sediment accumulation and characteristics, were routinely monitored. The results from small-scale tests of the AirX diffuser indicated oxygen transfer efficiency up to 20% at oxygen levels of 70 – 80% DO saturation in a seawater tank. Moreover, in waters where stratification occurs, oxygen levels can be even lower at the diffuser's depth, which might increase the efficiency. Thus, it was estimated that the system would be able to control the running DO concentration above 70 – 80% of saturation assuming sufficient air supply.

In sea cages, it is possible to inject air at larger depths than in the earth ponds. This will increase the contact time between air and water, and thus increase the oxygen transfer. However, care must be taken when injecting pressurized air at large depths to avoid gas super-saturation which may result in potential harmful conditions for the fish. It is therefore important to select appropriate injection depth and practice. Moreover, it is highly recommended to monitor the total gas pressure (TGP) when aerating continuously at large depths (> 3 – 4 m).The aeration system has been running at the Greek fish farm for several months, injecting air at 4-5 m depth without any indications of negative effects for the fish or signs of elevated TGP. The diffuser system managed to lift the mean DO in the cage by some 8% during August, even though the oxygen levels were very high (85 – 90 % of saturation).

Small-scale tests with gilthead sea bream
Detailed studies were performed in indoor tanks at IPMA to improve the knowledge base about the required DO control in sea bream aquaculture. In brief, lower than 80% of DO saturation reduced growth rate and feed utilization, and also indicated higher haematocrit levels. Thus, DO should be kept above this limit throughout the production cycle in order to utilize the production potential of sea bream and maintain the fish's welfare. Within a fish density range of 5 – 20 kg m-3, no significant differences were found with regard to performance of sea bream. The outcome of these studies will be published in a scientific journal.
Potential Impact:
Oxygen deficiency can constitute a challenge in aquaculture, especially when water temperatures are high. This challenge manifests itself in decreased appetites, low-level feed utilisation, slow growth rates, increased stress among the farmed stock, and higher production costs. The factors resulting in oxygen deficiency typically coincide during summer and early autumn – at a time when the stocking densities are normally quite high. This can result in prolonged periods with low oxygen levels, making it necessary for the farmer to alter husbandry practices in order to reduce the need for oxygen.

The AirX project has developed and tested a new technology that uses air to control dissolved oxygen levels in aquaculture. The concept, which has already been patented, is designed for use in large farming facilities, including earth ponds, sea cages, tanks and raceways. Currently, cage farmers rely singularly on the ability of the sea current to replace oxygen consumed by farmed fish. In earth ponds, on the other hand, aeration devices such as paddle wheels and air jets are commonly used.
However, the existing aeration devices used in ponds have low efficiency, whereas for cages there are no realistic options available. At critical periods with low oxygen levels, feeding is reduced and productivity of the industry is heavily influenced. Mortalities may appear accumulated stress may result in decreased appetite and thereby decreased growth, and decreased feed utilization.

Tests have shown that AirX is able to add oxygen in an efficient and homogenous manner throughout the water volume. The diffusers system is also designed to direct diffusion towards areas in the rearing unit where oxygenation is mostly needed. Other benefits of using AirX for the end-users are higher growth rates of stock, improved feed conversion rates, higher production capacities, and reduced energy costs. Under lab-scale conditions, the best in test diffuser hose attained an aeration efficiency of 2.7 kg O2 transferred from air to water per KWh of electricity consumed. Given electricity price of 0.11 EUR/kWh, this translates to 0.04 EUR/Kg O2 added to the water. However, under the large-scale field trials, the electricity consumption was higher as the backpressure in the hoses increased over time. Measures taken to overcome this has not been as successful as could be wished, resulting in a higher energy consumption than the targeted 0.5-1.5 kWh per kg O2 added. The estimated consumption for the field trials are at 0.2 EUR per kg O2 added. However, this still represents a potentially cheaper alternative compared to injecting pure oxygen gas under similar conditions using submerged diffusers, which costs 0.25-0.64 EUR per kg pure O2-gas.

The target market for the AirX system are cage and earthen pond farmers in the Mediterranean, which periodically experience problems with reduced growth rate, increased feed conversion factor (FCR), stress and mortality of stock

due to low oxygen content in the water. Other relevant markets include pond farming of fish and shrimp in Asia and in the Americas, and also for restoration of lakes.

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