Aeration: the Facts

The high production rates needed for profitability in freshwater pond aquaculture (such as semi-intensive marron farming and silver perch farming) and some forms of mariculture (such as prawn farming) are just not possible without some form of aeration and circulation to cope with the necessary high feeding and stocking rates. The need for aeration is mostly now accepted by Industry. But there is still some controversy as to which is the most efficient method of aeration and circulation.

Aerator Functions

Aeration and circulation of the water is one of the most essential issues in intensive and semi-intensive aquaculture. Aeration and circulation are usually both performed at the same time by a well designed unit. In ponds, a number of functions are performed by a good aerator:

1. It adds oxygen directly to the water (oxygenates). Compare Fig. 1c (no oxygenation) with Figs. 1a, b, d, e and f (range from some to good oxygenation).

2. It circulates or mixes the water top to bottom to ensure that the oxygen content is uniform throughout the pond (this is especially important when a bottom dwelling animal which cannot come to the surface, such as marron, is the culture species). Figs. 1a - e all show verticle mixing but it requires the combination of function 3 below to be effective.

3. It moves aerated water away from the immediate area around the aerator while dragging in unaerated water rather than retreating the same water. Compare Fig 2a (poor circulation) with Fig. 2e (good circulation) or Figs. 1a - d (poor circulation) with Figs. 1e and f (good circulation).

4. With deeper organic sediment layers in ponds, it creates an oxidised surface layer through which toxic gases and chemicals, such as hydrogen sulphide and ammonia, cannot pass through into the water above.

5. Circulation encourages other harmful gases and excess nitrogen and carbon dioxide to escape to the atmosphere.

Fig 1a Diffused Air

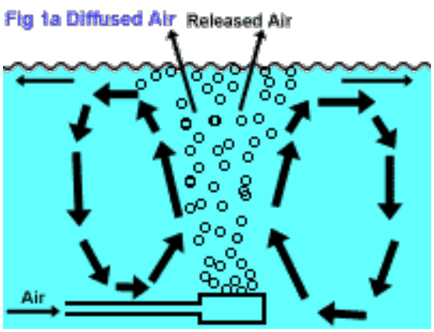
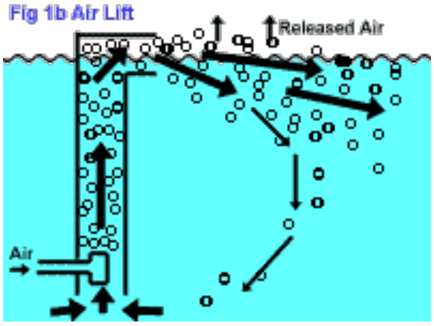


Fig 1b Air Lift



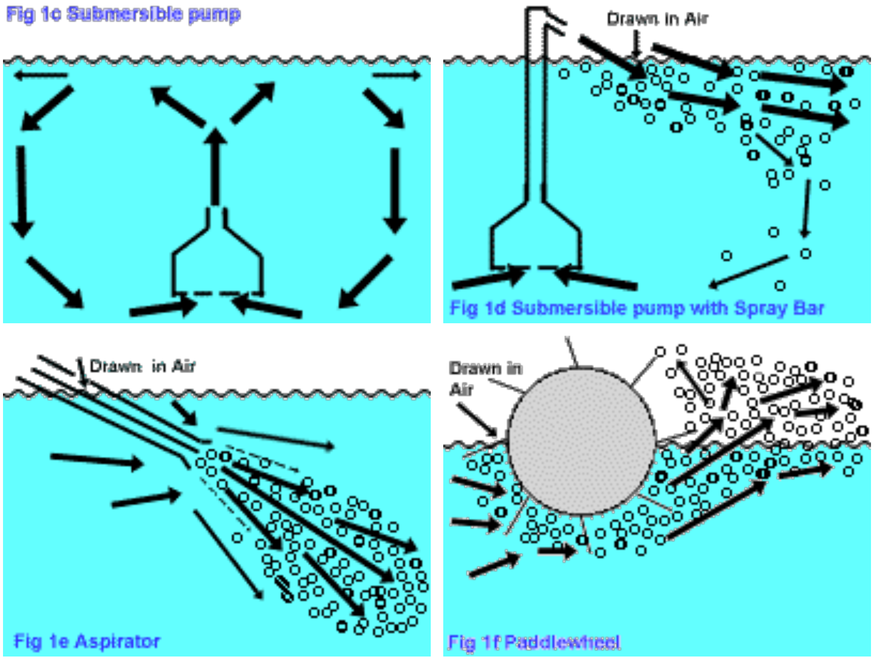


Fig 1c Submersible pump
Fig 1d Submersible pump with Spray Bar
Fig 1e Aspirator
Fig 1f Paddlewheel

Once an aeration system is installed it is important that it is checked to ensure that it is effective. A number of parameters should be monitored at regular intervals. This involves a combination of tests for oxygen concentration, redox potential and sediment cores. The oxygen measurements are best taken with a properly maintained reputable electronic oxygen meter with temperature and both percent saturation and mg per litre scales. Oxygen content should be checked at a number of sites and depths within a pond at various times of the day and night with particular attention paid to times of known low oxygen (early morning). Redox at the bottom sediment - water interface can also be measured with an electronic meter but is difficult. Sediment cores are a visual check for oxidised (the brown surface layer) and anaerobic layers (black layer), the oxidised layer ideally should be 2cm deep with the anerobic layer below this. If there is no oxidised layer and deep black sediment over the clay base of the pond you have a serious problem which can be best solved by aeration.

Diffused Air

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This type of aeration in large shallow aquaculture ponds is almost completely ineffective as it generally only performs functions 1 and 2 in a limited capacity. This form of aeration regularly comes in as the least cost efficient form of aeration. The efficiency of this type of aeration is also greatly dependent upon the size of the bubble (the finer the bubble the greater the efficiency but fine diffusers foul or block more rapidly) and the way in which they are installed (loose or in airlifts). Purpose-built aquaculture ponds are generally shallow (1-2m) and since this type of aeration is also dependent upon the contact time between the water and the bubble the Department of Fisheries is usually just not enough to allow long contact times, although U-tube airlifts can be used to improve contact duration. It is however a good system in deeper water (>5m) such as water supply dams. The use of a number of air diffusers scattered around a pond is probably the most inefficient system and the aeration effect is usually very localised around the diffuser (Fig 1a). Air lifts can be used to improve mixing and help generate currents (Fig 1b). Boyd (1995) described a shallow pond compressed air aeration system that performed well but would probably not be suitable for crayfish production. Generally diffused-air is the most inefficient way to aerate a pond when the hp required or dollar cost per unit of oxygen is calculated (refer to Table 1).

Fig 2a Aerator Placement (from Boyd 1989)

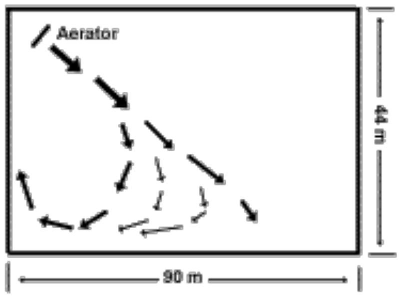


Fig 2b Aerator Placement (from Boyd 1989)

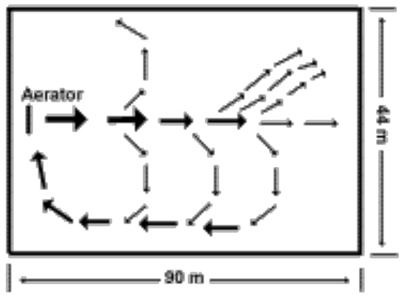


Fig 2c Aerator Placement (from Boyd 1989)

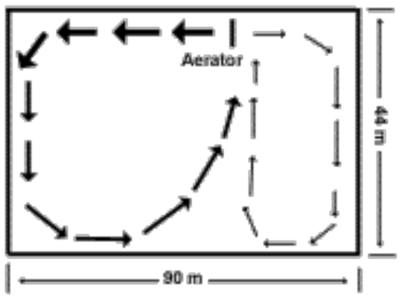


Fig 2d Aerator Placement (from Boyd 1989)

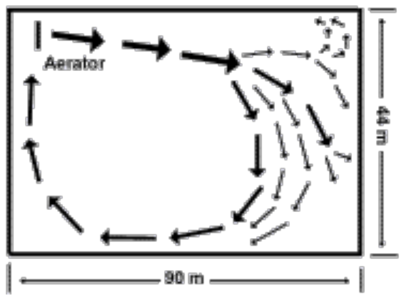
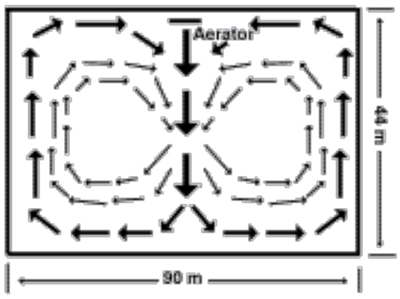


Fig 2e Aerator Placement (from Boyd 1989)



Diffused-air or trickle aeration is not recommended in large shallow growout ponds or in smaller broodstock/nursery ponds, however it is quite suitable for hatchery and purging tanks due to their small size or, if installed correctly and power is available, in deeper farm dams used for marron or yabbie harvesting.

Submersible Pumps

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The use of submersible pumps near the bottom of a pond with the outlet pointed at the surface, depending on the size of the pump, provides some circulation/mixing (function 2) of the pond water but like air diffusers this can be localised (Fig 1c). It does not however add any oxygen directly to the water except through diffusion by exposing poorer quality water to the surface. If you use this type of device it would be better to extend the outlet above the surface and provide a spray bar to spray the water back into the pond (Fig 1d). This is an inefficient way to aerate a pond when the hp required or dollar cost per unit of oxygen is calculated (refer to Table 1).

This type of aeration is not recommended for large growout ponds(1000m^2) but with the spray bar it is suitable in small broodstock and nursery ponds (100-200m^2).

Propeller Aspirator Pumps

Propeller aspirator pumps are good circulators and aerators in ponds (Fig 1e) but are designed more for deeper waters (1-5m) and their efficiency is similar to that of the Nan Rong style of paddlewheel (Table 1). Nan Rong (a Taiwanese Company that manufactures aquaculture equipment as well as running their own aquaculture farms) is at present the main supplier of propeller aspirators (and paddlewheels) into W.A. They produce a 1hp single or 2hp three phase version at around A$760 (when brought in as a full container) which is slightly more expensive than the paddlewheel price, but as the manufacturer recommends 6 units/hectare (1800m^2/unit) this may also be excessive in a normal size (1000m^2) marron pond. When used in shallow ponds they have a tendency to scour hollows where the water stream collides with the pond bottom so care must be taken when they are installed to avoid this problem.

These types of aerators would be more suitable for farm dam marron or yabbie harvesting operations that wish to increase production by providing additional feed although the cost of connecting mains power is usually prohibitive.

Paddlewheel Aerators

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Paddlewheel aerators are the most widely used method of aeration and have proven to be efficient and suitable for marron farming growout ponds as well as the pond culture of most other Australian fish species. The paddlewheel is at present the most efficient aerator due to the combined way it rapidly destratifies a pond through strong water circulation (functions 2, 3 and 5) and aeration by spraying water into the air as well as dragging air into the water creating large surface areas of air/water interface (functions 1 and 5)(Fig 1f) allowing efficient gaseous exchange (oxygen in and harmful gas out). The combined effect of strong circulation and aeration allows the formation of the important oxidised surface sediment layer (function 4). None of the other aeration systems either perform all these functions or do them as efficiently. Nan Rong make a 1hp single or three phase paddlewheel at a cost of around A$650 (when brought in as a full container) and one paddlewheel works well in the standard marron pond of 1000m^2 and a maximum depth of 1.5-2m. Unlike some of the other systems (which may have to run for up to 24 hours to have the same effect) tests have shown that for marron farming the paddlewheel only needs to run for up to a maximum of one hour (20-30 minutes is usually sufficient) three times per day (just prior to sunrise, late afternoon and late evening). The amount of aeration required is dependent upon a number of factors so other species under culture may require more or less aeration than that for a standard marron pond as the pond may be of a different size/volume, feeding rates may be higher or lower, stocking rates may be higher or lower, the water temperature may be different and the species requirements need to be taken into account. Paddlewheels, in general, have the greatest oxygen increase per hp per hour as well as the least cost per unit of oxygen (Table 1). Recently after some urging from industry, Ivan Lightbody (WA Marine Labs Engineer) and Dave Owens (Electrician) conducted some comprehensive power consumption tests to prove that paddlewheels are not as expensive to run as some people believed (Table 2).

This type of aerator is recommended for large (1000m^2) shallow growout ponds such as those used in marron and silver perch farming. Paddlewheels can also be used in smaller broodstock and nursery ponds but a 1hp unit is overkill.

Location of Pond Aerators

There are a number of locations within ponds that have been used over the years for the placement of aerators. Some of these locations are inefficient or create dead spots (areas of little mixing resulting in low oxygen) within the pond. According to work carried out by Claude Boyd (1989) for catfish ponds (40m by 90m), the aerator should be placed in the middle of the long axis to one side of the pond and faced across the pond (Fig 2e) for the greatest effect. However, due to the cost of running power along the long axis of a pond system, most marron farms place the paddlewheels in the deep end (usually central to the short axis) and facing along the long axis of the pond (Fig 2b).

When installing paddlewheels and other mains power electrical devices care must be taken in the way in which they are installed, they are an electrical device in water and safety is paramount. Check with Western Power or local electrician for the requirements in your area as they can differ slightly. Generally the following apply:

1. The lead running from the motor to the power point should be no longer than necessary otherwise a heavier duty cable may be required which draws more amps resulting in a higher electrical consumption.

2. The cable to the motor should be covered with a catenary wire (a protective sheath or support wire).

3. It is recommended that a residual current device or isolated transformer be used for safety reasons.

4. Power point and plug should be waterproof (Australian Safety Standards 3000).

Fig 3 Aerobic and Anaerobic Layers

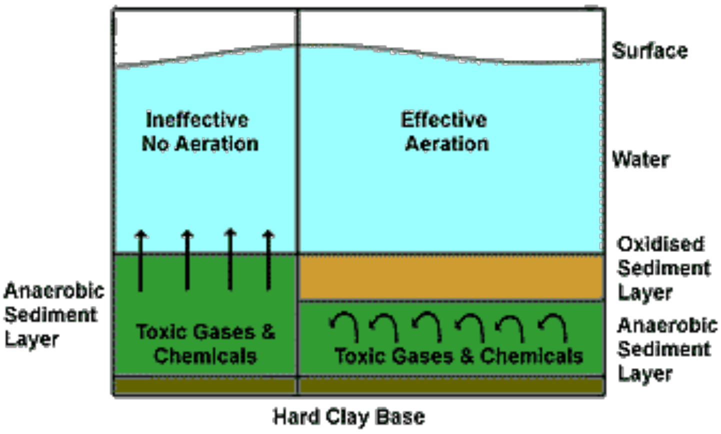

Table 1: Average Standard Aerator Efficiency (SAE) Values *(from Boyd and Ahmad 1987, Boyd 1996)* ***and Operating Costs for Electric Aerators.***		
Type of Aerator	**Average SAE lb O_2/hp-hr**	**Average Operating Cost cents/lb O_2**
Paddlewheel (Auburn Uni. Spiral design)	4.5	
Paddlewheel (average)	3.5	4.8c
Paddlewheel (Nan Rong type)	2.5	
Propeller aspirator	2.6	5.4c
Pump sprayer	2.1	7.2c
Diffused air	1.6	8.6c

Table 2: Power consumption and cost for a 1hp (nominal) Nan Rong paddlewheel aerator run for 1/2 hour 3 times per day. [Cost is GST inclusive as at 10/11/2000] Running motor draws 5.6-6 amps (1.5kw/hour)		
	Normal Tariff *	
	Residential	**Commercial**
Rate/unit (kw)	13.94c/unit	17.47c/unit
Paddlewheel cost/hour	20.91c/hr	26.20c/hr
Paddlewheel cost/day	31.37c/day	39.31c/day
Paddlewheel cost/year (365 days)	$114.50/year	$143.48/year
Paddlewheel cost/year (275 days) (off winter)	$86.27/year	$108.10/ year

* There is an off-peak tariff option for residential and commercial properties that is cheaper than the normal tariff but a special meter must be purchased and fitted. This tariff varies depending on the day and time of day. For example, the current commercial off-peak tariff for commercial properties is 5.9c/unit all weekend and from 10pm to 8am weekdays.

Acknowledgments

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Suggested Further Reading

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