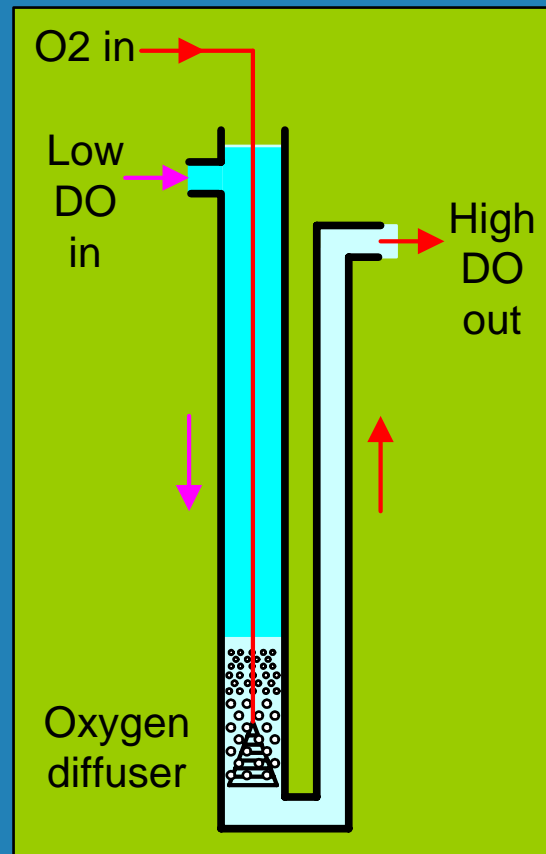


# *Hatchery Applications of a Counter-Current Oxygen Contactor (Farrell Tube)*




- \* Simple, On-site Construction
- \* Low Head – as little as 3 feet
- \* 90% Oxygen Transfer Efficiency (OTE)
- \* Low Maintenance



## *California State Mandates for Increased Hatchery Production*

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- ❖ *California Fish And Game Code Section 13007:*
- ❖ *By January 1, 2010, 10 percent*
- ❖ *By January 1, 2011, 15 percent*
- ❖ *By January 1, 2012, 25 percent*



## *Production Limitations (Fish Stressors)*

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- *Water flow*
- *Dissolved oxygen (DO)*
- *Un-ionized ammonia (NH<sub>3</sub>), nitrite (NO<sub>2</sub>), carbon dioxide (CO<sub>2</sub>)*
- *Water volume (crowding)*



## *Methods for Increasing Fish Production*

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- *Increase water flow*
- *Improve feed utilization*
- *Supplement oxygen*
- *Recycle water*



## *Increased Production Through Feed Selection and Management*

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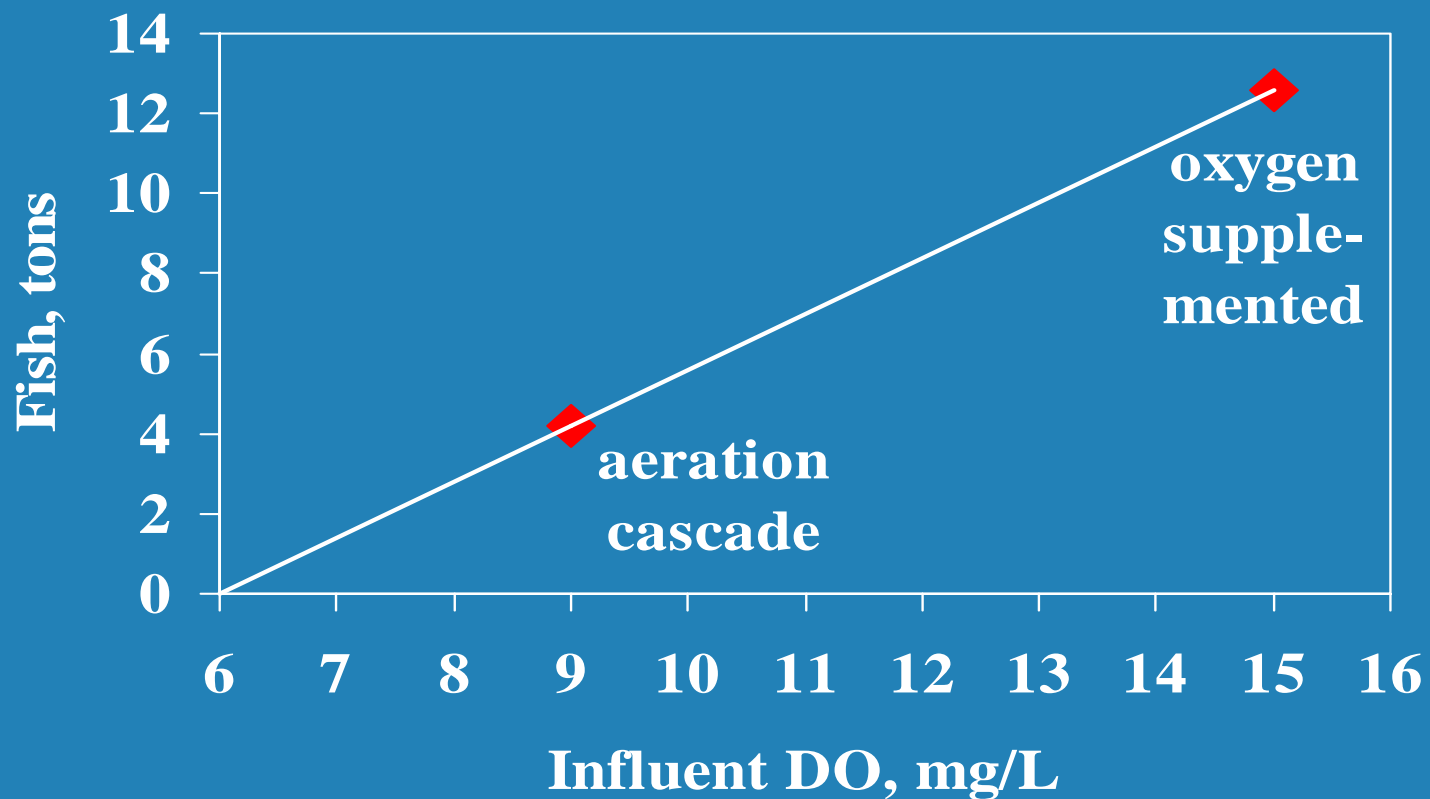
- *Feeding regimen → feed utilization and waste.*
- *Feed formulation → digestibility and nutrient utilization.*
- *High quality feed → reduced solid and dissolved metabolic wastes, reduced COD.*



## *Increased Production Through Oxygen Supplementation*

- *Increase production capacity of existing facilities by 1.7 to 3.0 times (Colt and Watten, 1988).*
- *Up to 25% production increase for each 1.0 mg/L DO increase (Westers, et al, 1988).*

# *Fish Stocking versus Inflow Dissolved Oxygen (DO) for a 3 cfs (1,350 gpm) Raceway*





## *Raceway Cascade Aeration Limitations*

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- *Air oxygen saturation*
- *Oxygen transfer efficiency (OTE)*
- *Raceway tail-water oxygen depletion – crowding at the head-water*





## *Pure Oxygen Supplementation Options and Economics*

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- *Sources: Liquid oxygen tanks and oxygen generators*
- *Oxygen transfer efficiency (OTE)*
- *Pumping – power consumption, maintenance and replacement*

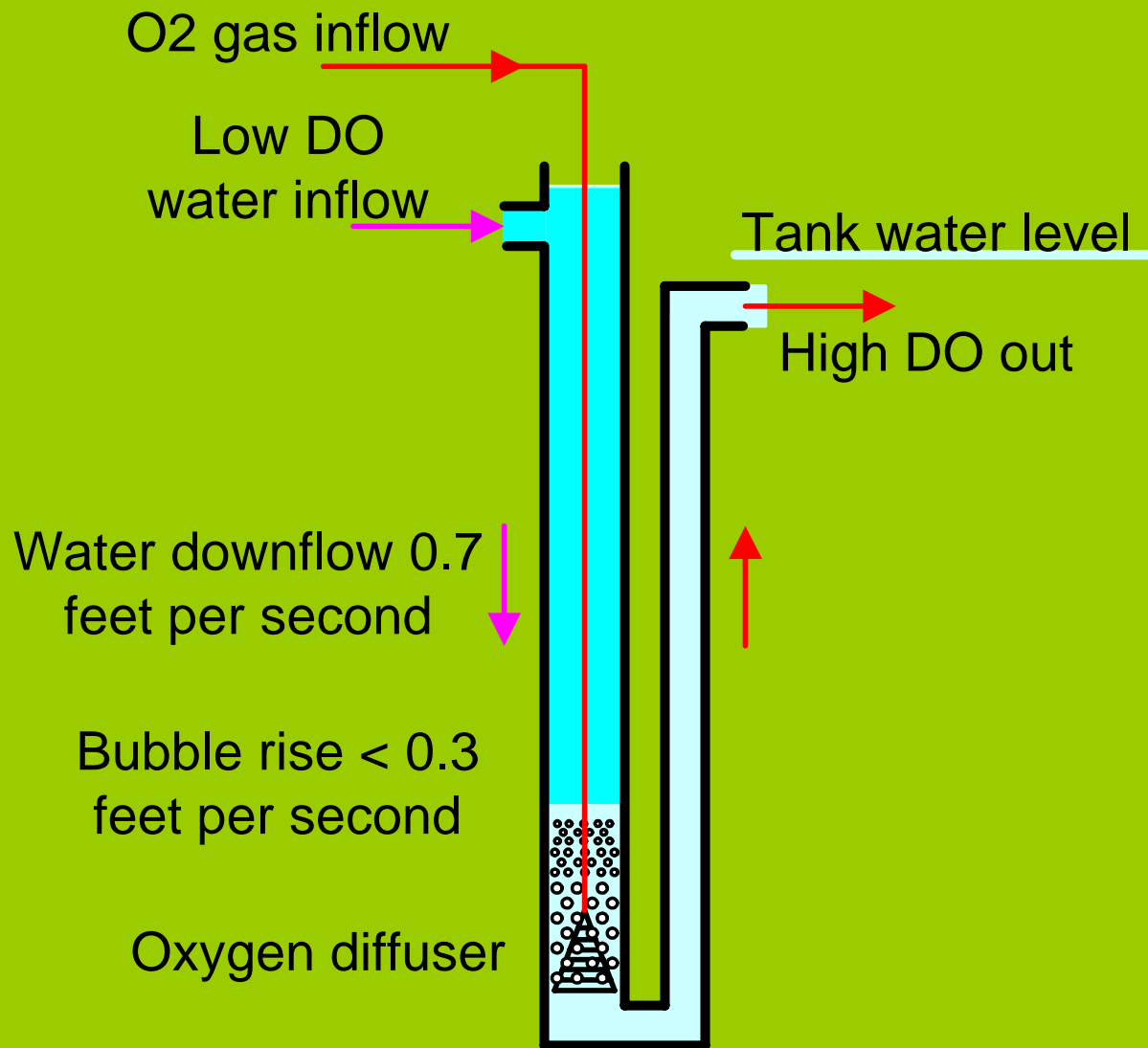


# *Oxygen Transfer Devices*

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- *Low-head Oxygenators (LHO's)*
- *Packed Columns*
- *Farrell Tubes*

# *The Farrell Tube*





## *Raceways and Circular Tanks*

- *Raceways: plug flow. O<sub>2</sub> injection rate limited by headwater gas super-saturation constraints.*
- *Circular Tanks: mixed flow. Immediate dilution prevents gas super-saturation.*



## *Farrel Tube Field Performance*

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- *As little as 3 feet head pressure*
- *One mg/L DO increase per foot of Farrell Tube depth*
- *Oxygen transfer efficiency (OTE): 90%*
- *Oxygenation energy efficiency: 14 kgO<sub>2</sub> per kW*

# *40-foot Farrell Tube*





# *130-foot Farrell Tube*

