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

- **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)

- Water flow
- Dissolved oxygen (DO)
- Un-ionized ammonia (NH3), nitrite (NO2), carbon dioxide (CO2)
- Water volume (crowding)
Methods for Increasing Fish Production

- Increase water flow
- Improve feed utilization
- Supplement oxygen
- Recycle water
Increased Production Through Feed Selection and Management

- 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

![Graph showing the relationship between Influent DO, mg/L and Fish stock, tons. The graph indicates a linear increase in fish stock with increasing DO levels, marked as oxygen supplemented aeration cascade.]
Raceway Cascade Aeration
Limitations

- Air oxygen saturation
- Oxygen transfer efficiency (OTE)
- Raceway tail-water oxygen depletion – crowding at the head-water
Pure Oxygen Supplementation
Options and Economics

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

- Low-head Oxygenators (LHO’s)
- Packed Columns
- Farrell Tubes
The Farrell Tube

- **O2 gas inflow**
- **Low DO water inflow**
- **Tank water level**
- **High DO out**
- **Water downflow 0.7 feet per second**
- **Bubble rise < 0.3 feet per second**
- **Oxygen diffuser**
Raceways and Circular Tanks

- **Circular Tanks**: mixed flow. Immediate dilution prevents gas super-saturation.
Farrel Tube Field Performance

- 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 kgO2 per kW
40-foot Farrell Tube
130-foot Farrell Tube