Harvest & Transport Best Management Practices

J. Alan Johnson, Rathbun Fish Culture Research Facility, IDNR
Robert Summerfelt, Professor Emeritus, ISU

**Presentation for NCRAC Aquaculture Conference, Toledo, OH.
February 22-23, 2014**

Overview

- Purpose of transport
  - Fisheries enhancement, long-term survival.
  - Live haul to fish market; short-term survival.
  - Direct to slaughter facility.
- Walleye transportation study: Review physiological processes.
- Best Management Practices
- Transport density survey

Walleye transport study

- Transport walleye fingerlings (~200 mm)
  - Sport Fisheries enhancement stockings.
  - Duration of about 5-6 hrs.
- Three-year study compared:
  - Yearl 1: Vented and unvented transportation.
  - Year 2: Vented and Ram vented transportation.
  - Year 3: Buffered water in a Ram vented tank.
- Physiological processes during:
  - Harvest and loading
  - Transport
  - Post-transport

Pre-harvest preparation

- Suspend feeding
  – Small fingerlings 12-24 h
  – Large fingerlings 24-48 h
- Physiological Basis
  – Clears gut and reduces production of solid wastes.
  – Reduces the post-feeding increase in O_2 consumption and NH_3 excretion.

Harvest

Loading fish

Harvest and loading stress

- Efforts to capture increases fish's muscular activity, production of lactic acid (acidosis), and an oxygen debt.
- Physiological Measures of Stress in Plasma:
  - Cortisol, Glucose, Chlorides
- Stress effects
  - Cortisol increase causes branchiodilation to increase gas exchange, but water uptake is increased.
  - Chlorides decrease (loss through diuresis).
- Consequence: Substantial increase in inflow of water through the gills, causing life-threating loss of the electrolytes (Na and Cl).

Year 1: Harvest and loading stress

	Cortisol			Chlorides		
	Trip 1	Trip 2	Trip 3	Trip 1	Trip 2	Trip 3
Pre-loading raceway	20.2	0.6	41.1	116.6	101.1	102.5
Post-loading	71.7	54.4	128.9	93.4	97.0	106.8
End of trip	82.9	17.9	71.5	77.1	90.9	109.8
Day after	34.6			70.8		

*Trip 1, 2 tanks were unvented, Trip 3 was vented.

Evidence for stress: Cortisol values triple after loading, decline.

Trips 1 and 2 : 0.25% NaCl in tank water, but blood chlorides decrease after loading and do not recover.

Trip 3 had 0.5% NaCl in tank water and blood Cl remained steady.

Fish hauling tanks may have great features

Source: Unknown

Fiberglass, aluminum, stainless steel with dump gates, oxygen flow meters, openings for mechanical aerators, and latching lids with tight seals.

Fresh-flo Corp, Sheboygan, WI

Compressed oxygen tanks or liquid oxygen (LOX)

And more…

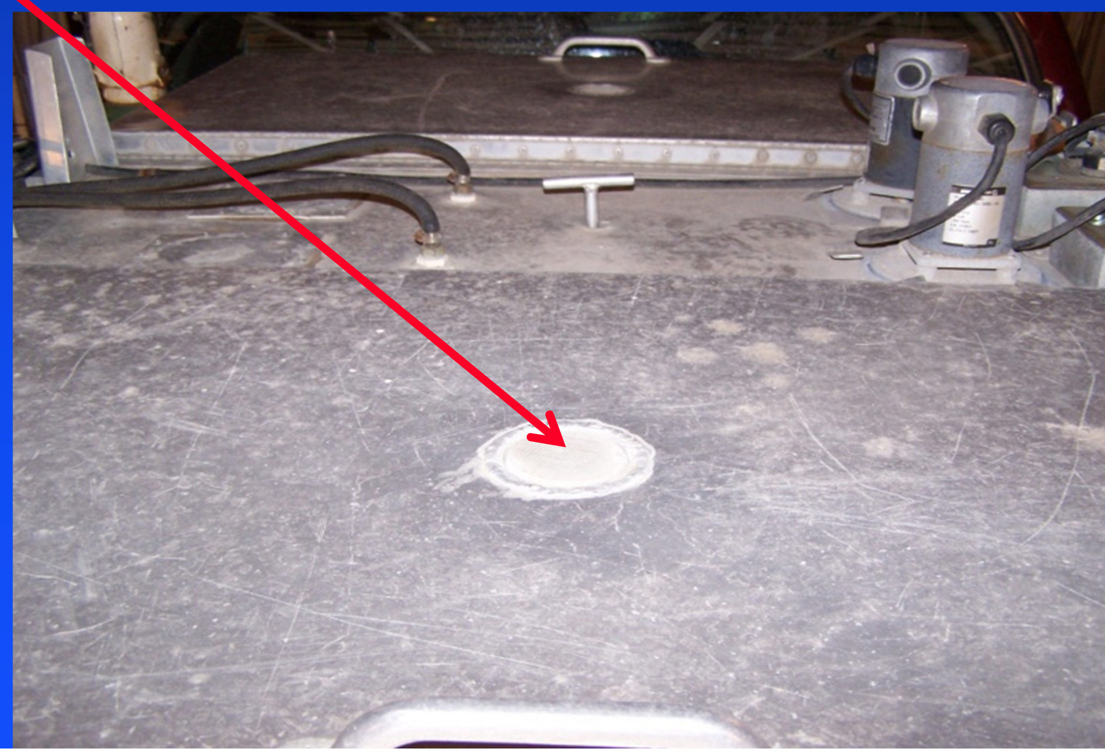
Oxygenation and monitoring

- OxyGuard Pacific 8 Monitoring System.
  - DO probes in each tank
  - 8 channel splitter
  - Display in cab
    - 1- 4 conductor cable from main unit to the channel probe Unit.
    - Simplified connectivity.

But…

Many transport tanks

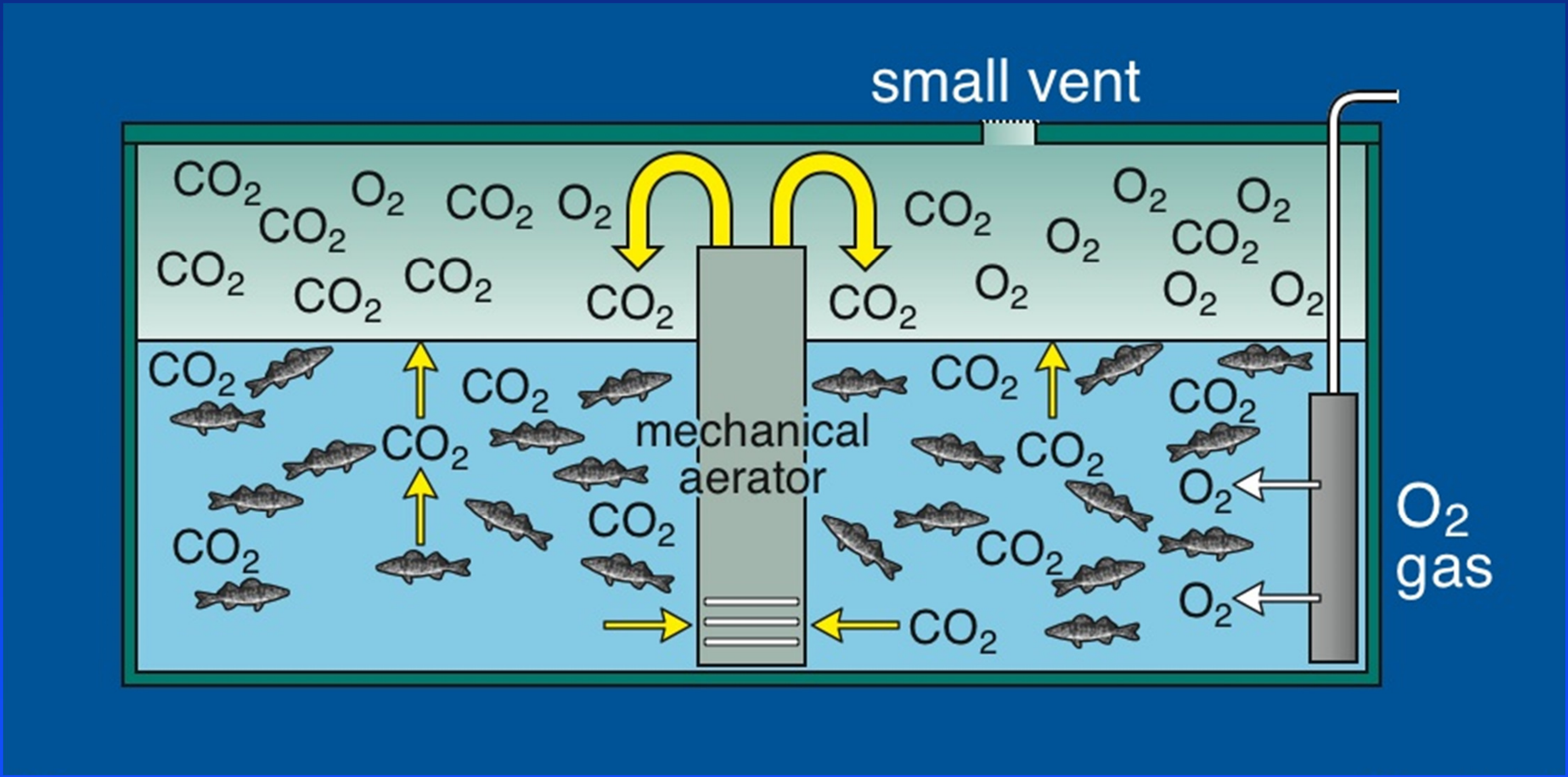
- Are not equipped to monitor oxygen
- Nor are they equipped to remove CO_2.
- Most tanks have no opening or only a small opening in the lid for air exchange.



CO_2 in tank with small opening in lid

- Aerator moves CO_2 from water to air space, but soon high pCO_2 in air reduces exchange of CO_2 from water.
- Use of compressed or liquid O_2 is required for high densities of fish. But without monitoring and mechanical aeration, supersaturation and hyperoxia develops.
- Oxygen supersaturation reduces gill ventilation rate, thus reduces elimination of CO_2 from the blood.

CO_2 in tank with small opening in lid



Year 1: Comparison of CO_2 in tanks with and w/o a vent*

	Without vent		With vent	
	CO_2	O_2	CO_2	O_2
Pre-load	46.1	9.5	29	9.5
Loaded	58.7	9.4	57	8.7
End of trip	64.7	13.4	64	12.2

*Ventilation was a 6.3 cm hole, which was covered in unvented tanks.

<u>Small vent</u> in lid did not improve water quality compared to no vent.

CO_2

"Failure to adequately remove dissolved CO_2 results first in hyper-capnia and acidosis, then respiratory stress from the Bohr and Root effects, tissue hypoxia, and eventually CO_2 narcosis and death (Wedemeyer 1996)"

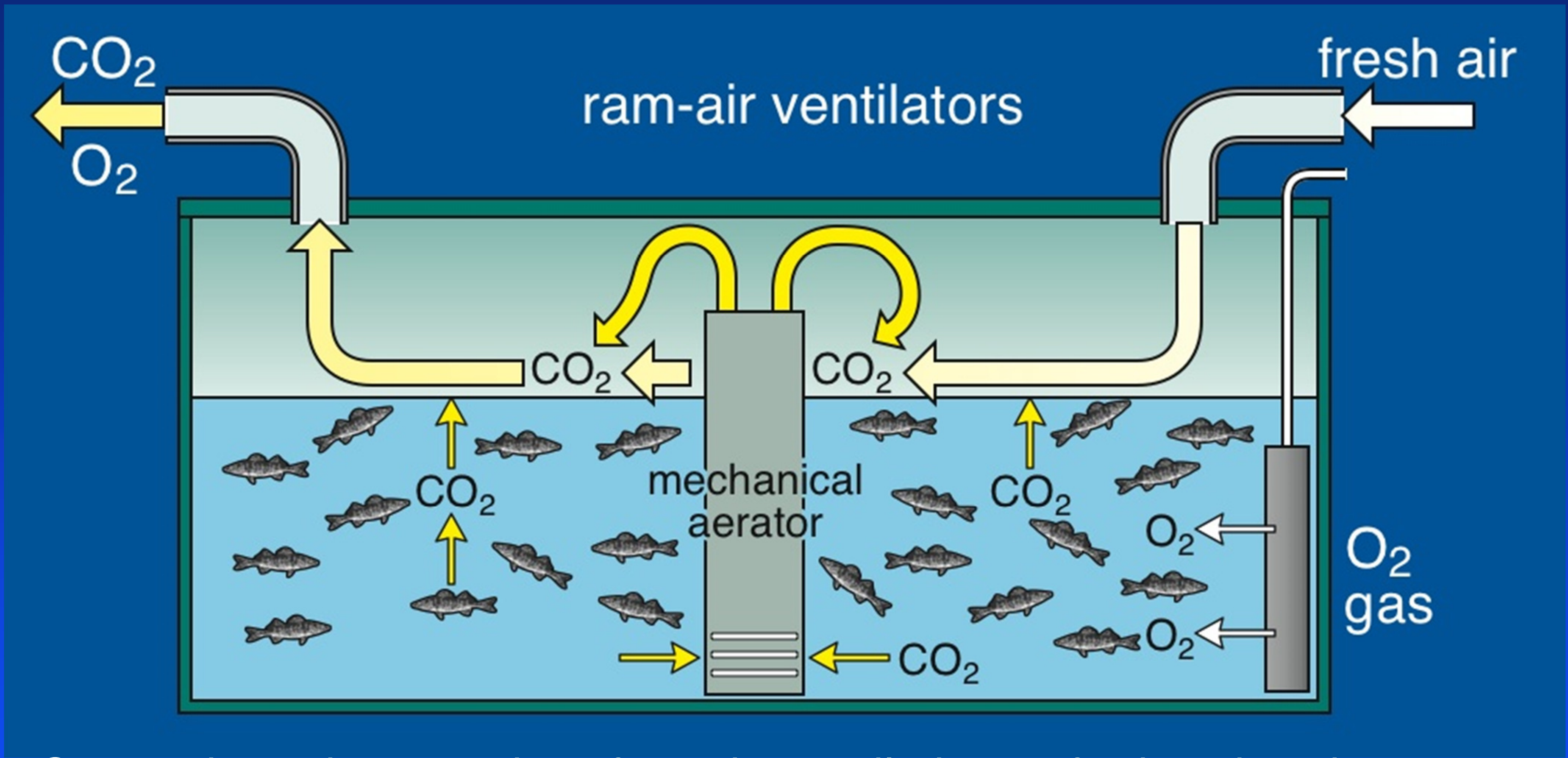
CO_2 induces characteristics of anesthesia

– Loss of equilibrium

– Non-responsive to audio/visual, tactile stimuli

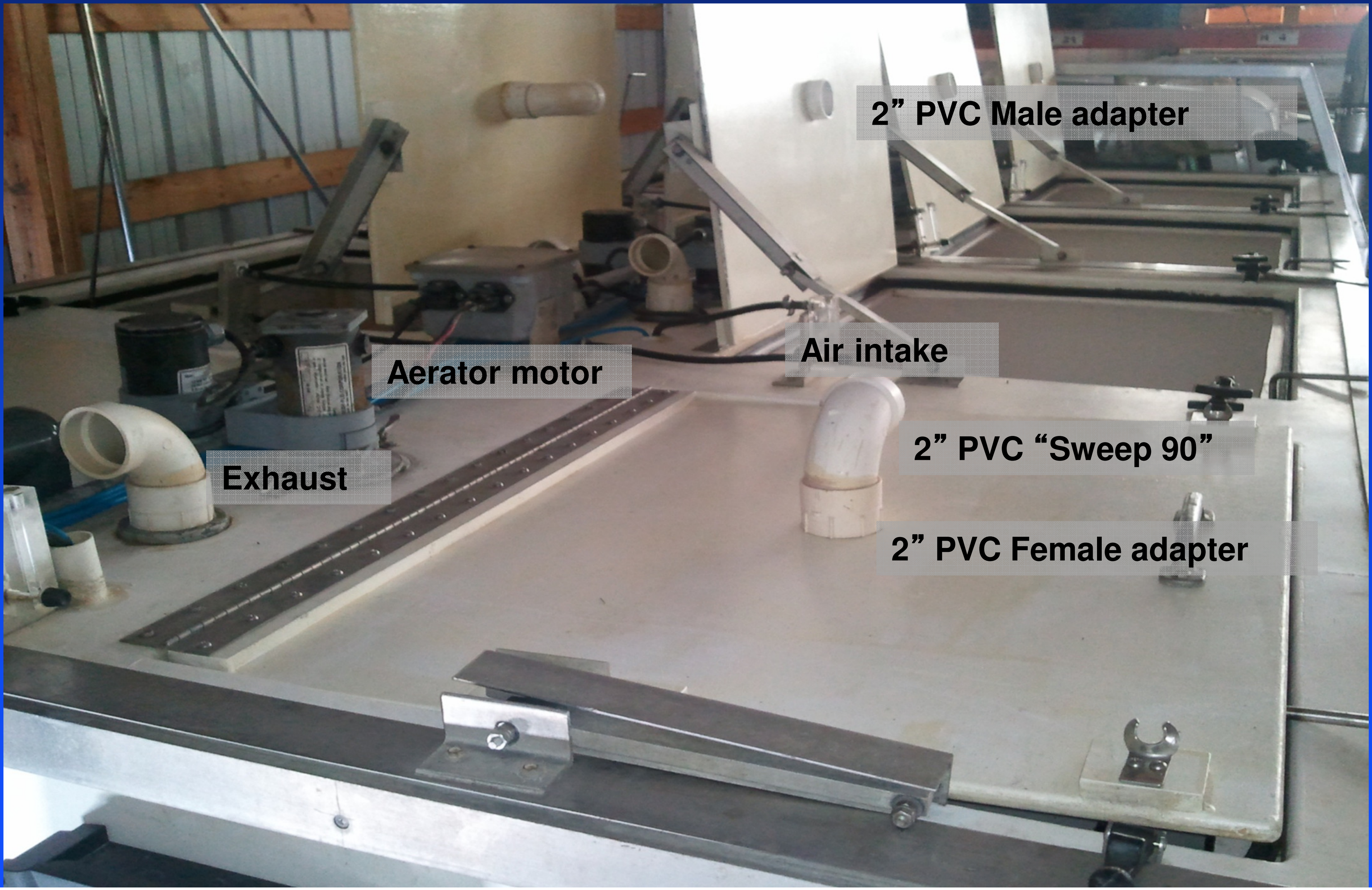
– Ventilation rate slow

Tanks with ram vents

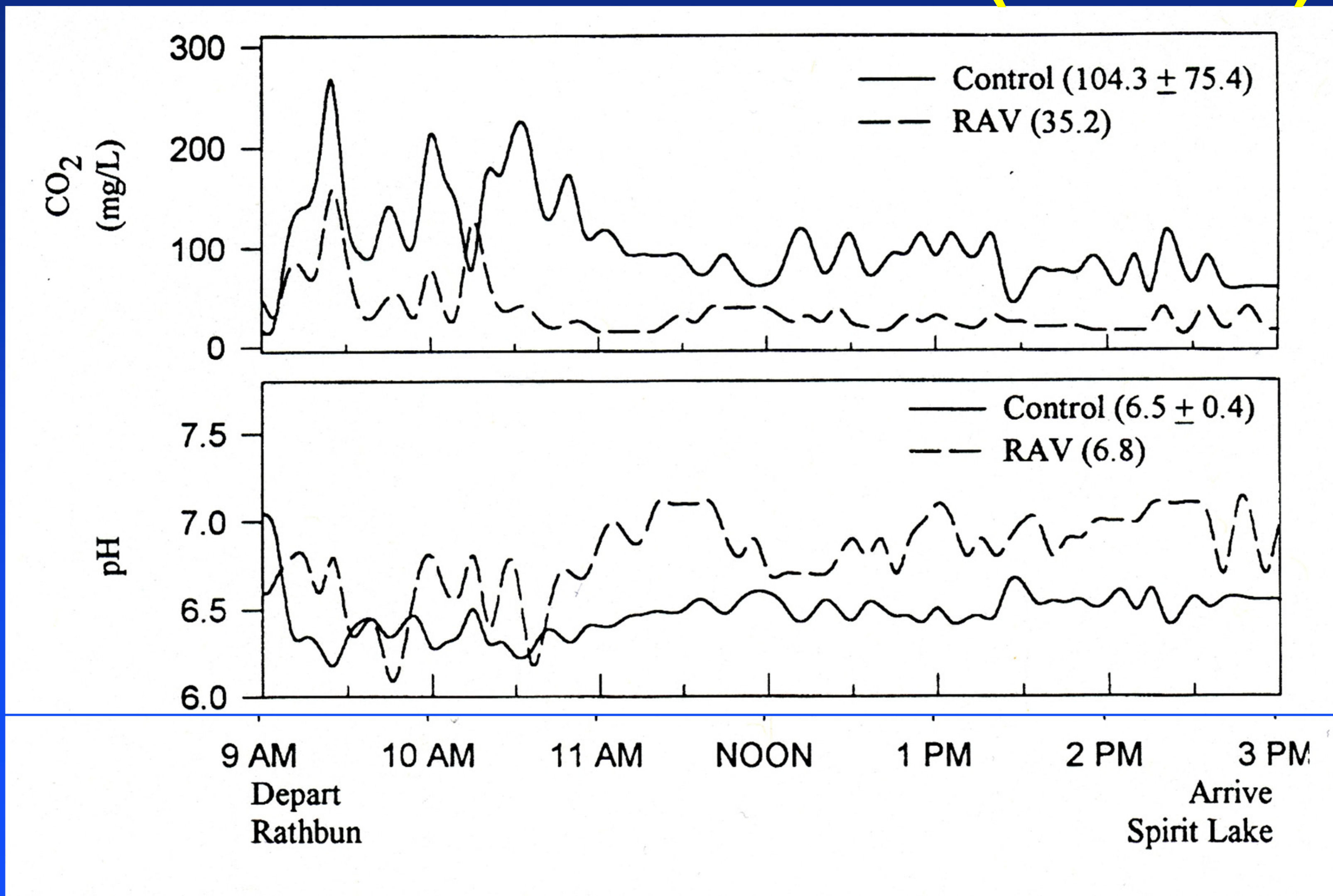


"Covered tanks require forced ventilation of the headspace to continuously remove CO_2 stripped from the water by the aeration system. Air scoops or vents mounted on the top surface can be used to provide the required airflow by ram ventilation while the hauling vehicle is in motion (Wedemeyer 1996:page 127)."

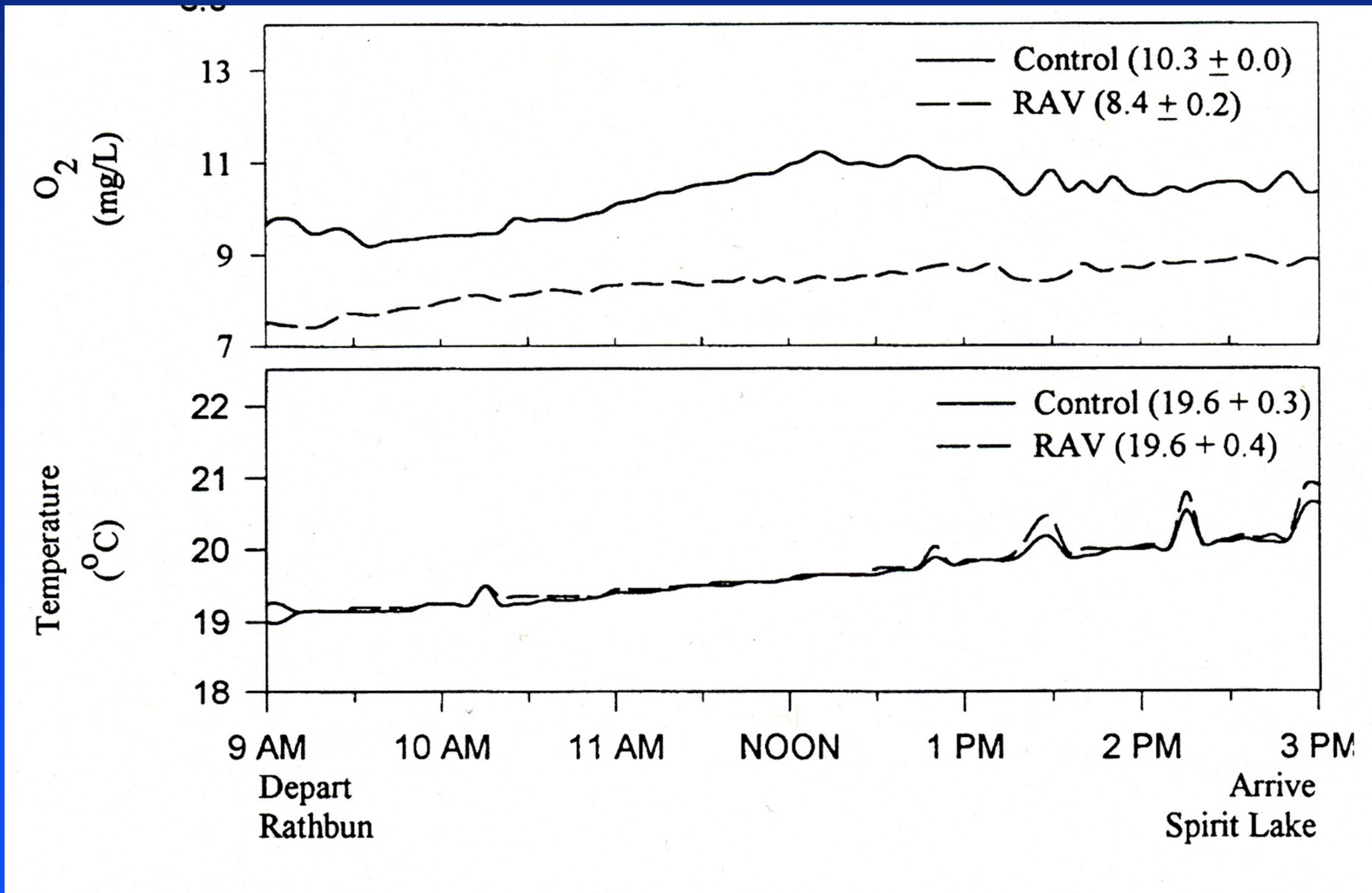
Ram Ventilation Design



Year 2: CO_2 and pH in tanks with RV or small lid vent (control)



O_2 and temperature in tanks with RV or small lid vent (control)



Comparison of blood parameters in tanks with and w/o RV

	pCO_2		pO_2		HCO_3	
	W/O	RV	W/O	RV	W/O	RV
Pre-load	11.8	10.4	7.4	6.1	10.7	9.8
Post-load (tank lids open)	11.2	10.1	8.0	10.5	9.9	11.9
Post-haul	19.8	9.0	6.7	7.5	21.5	14.6

High CO_2 shifting acid–base balance, increasing concentration of blood bicarbonate in unvented tanks

$CO_2 + H_2O \leftrightarrow H^+ + HCO_3^-$ drops pH

Bohr effect of CO_2 reduces O_2 carrying capacity of Hb.

Year 3: Buffer use, water chemistry comparison

	pH	TAN mg/L	Alkal. mg/L	CO_2 mg/L
Preload	7.7			
Postload				
Control	7.34	1.15	87	8.2
Buffer	8.00	0.99	424	8.6
Posthaul				
Control	7.48	3.15	94	6.3
Buffer	8.26	2.80	426	5.1
Lake	8.6-9.2		166-194	0.2-1.0

0.05% sodium bicarbonate buffer.
Note: pH values of buffered water were more similar to lake water than the unbuffered water.

Year 3: Buffer use, blood chemistry comparison

Post transport observation in lake net pens:

- Post stock observations:
  - Cortisol reached a maximum of 175 to 204 ng/mL.
  - Blood CO_2 and Chloride at minimums.
- 24-h post haul recovery:
  - Cortisol returned to pre-loading levels.
- 72-h post haul recovery:
  - Chloride returned to pre-load levels.
- In one trip buffer reduced recovery time to return to pre-loading blood pH.

Summary of Effects on Blood Electrolytes

Stress of harvest and loading
—increase Cortisol.
—increases muscular activity and lactic production, potential for acidosis.
—causes increase in water uptake resulting in increased excretion (diuresis) and loss of chlorides.

Summary of Respiratory Effects

- In fish, oxygen controls ventilation.
  - Low oxygen increases ventilation, but
  - High oxygen causes a marked reduction in gill ventilation, thereby reducing elimination of CO_2 from the blood.
- High levels of CO_2
  - CO_2 lowers blood pH but homeostatic response is to compensate by increased blood levels of bicarbonate.
  - CO_2 produces the Bohr effect, reducing the ability of Hb to transport O_2 from the gills to the rest of the body.

BMPs for Harvest and Loading*

- Harvest only healthy fish.
- Discontinue feeding 24-48 h before harvest.
- Develop low-stress harvest procedures (gentle, softmesh netting to avoid physical injury, avoid crushing and loss of scales).
  - Evaluate light sedation to reduce stress.
- Need for the tanks to be well-oxygenated prior to loading because of the high demand.
- Tank covers must be open to vent CO_2 while stationary.
- Buffer and salt mixed in tank water before adding fish.

*See Table 1 chapter by Carmichael 2001 in Wedemeyer 2001 (FHM 2nd edition).

BMPs for Transport Tanks

- LOX tanks with micropore diffusers.
- Monitoring and control of oxygen concentration.
- Mechanical aeration
- Ram ventilation
- Salt (0.5% w/w)
- The need for buffering is based on alkalinity of water –
  - Sodium bicarbonate for water of low alkalinity (Wedemeyer 1996).
  - a tris buffer, **tris**[hydroxymethyl aminomethane] (5-10 mg/L) is recommended for general use (Piper et al. 1982)

Transport density survey

78% of state agencies reported: AR, IA, KS, MI, MO, NE, SD, TN, TX, VT, WI.

	States	Temp (F)	Survey Lb/gal	Piper et al. Lb/gal
Walleye				
8”	IA, WI	60-70	0.5-0.85	
	SD	45-55	1.0	
4”	IA, MO	70-85	0.5	1.3
	SD	45-55	1.0	
2”	7 states	65-77	0.25-0.5	0.55-0.6
	WI, MI	59-77	0.5-1.1	

Edwards KCl/Formalin treatment: IA, KS, MO.

0.075% KCl + 25 ppm formalin

NaCl is commonly used at 0.25% or 0.5% but rarely at 0, 0.75, 1%.

Transport density survey

78% of state agencies reported: AR, IA, KS, MI, MO, NE, SD, TN, TX, VT, WI.

	States	Temp (F)	Survey Lb/gal	Piper et al. Lb/gal
8” Channel Catfish	8 states	60-80	0.5-2.8	5.0
	TX	72-79	3.7	
	KS	70-80	2.0-1.2	
	KS	60-70	2.6-2.0	
	KS	<60	2.8	
2” *Morone* cross	6 states	65-86	0.25-0.60	
4” *Morone* cross	3 states	55-85	0.5 – 1.0	
8-10” Trout	8 states	41-60	1-2.0	2.5-3.5

Research Recommendations

- Determine walleye sensitivity to CO_2: 50 ppm catfish, 20-30 ppm salmonids.
- Determine maximum loading densities for transport:
  - Fish size
  - Temperature
  - Duration of travel
  - Evaluate BMPs for hauling tanks.
- Evaluated long term consequence of light sedation and stress on post stocking survival.