Asian Carp: Containment, Control, and Management in the Real World - Lessons Learned

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Introduction

- Chicago Area Waterway
  - Open connection between Great Lakes and Mississippi
  - Active shipping channel
  - Removal of sewage from Chicago

- Three electrified barriers exists to prevent movement of Asian carp into the Great Lakes
  - Successful to date?
  - Susceptible to small fishes
  - No non-physical barrier 100 % effective

- Supplemental barriers provide redundancy and safety
  - Longer term solution needed
  - Non-physical barrier ideal

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Introduction - GLMRIS Study

- Great Lakes and Mississippi River Interbasin Study (GLMRIS)
  - Identified options to prevent transfer of ANS
  - 8 alternative plans
- Components of alternatives:
  - Nonstructural controls
  - Structural controls
  - Buffer zones
  - Hydraulic separation
  - Combinations thereof
- Nonstructural controls
  - Nets
  - Chemicals
  - Boat restrictions
  - Education programs
- Structural controls
  - GLMRIS ANS locks
  - Electric barrier
  - Screened sluice gates
  - Other physical barriers

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Introduction - GLMRIS Study

- Major focus on maintaining transportation
- Costly alternatives
  - Capture and treatment of 500 yr flood volumes
  - New water treatment facilities needed to eliminate ANS passing through the locks
  - New infrastructure – reservoirs and tunnels to reduce flood risks
- HUGE timeline (implementation 25+ years in the future)
- Does not address stopping ANS like Asian carp immediately- diverted issues

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Introduction - Current Technologies

- Electric barrier
  - Ineffective for small fish
  - Barges reduces effectiveness
    - Configuration (rakes), residual flows
- Commercial fishing
  - Illinois River – up to 60% biomass
  - 5,000-10,000 lbs/day
  - ~2.5 million pounds in four years
  - Full eradication improbable

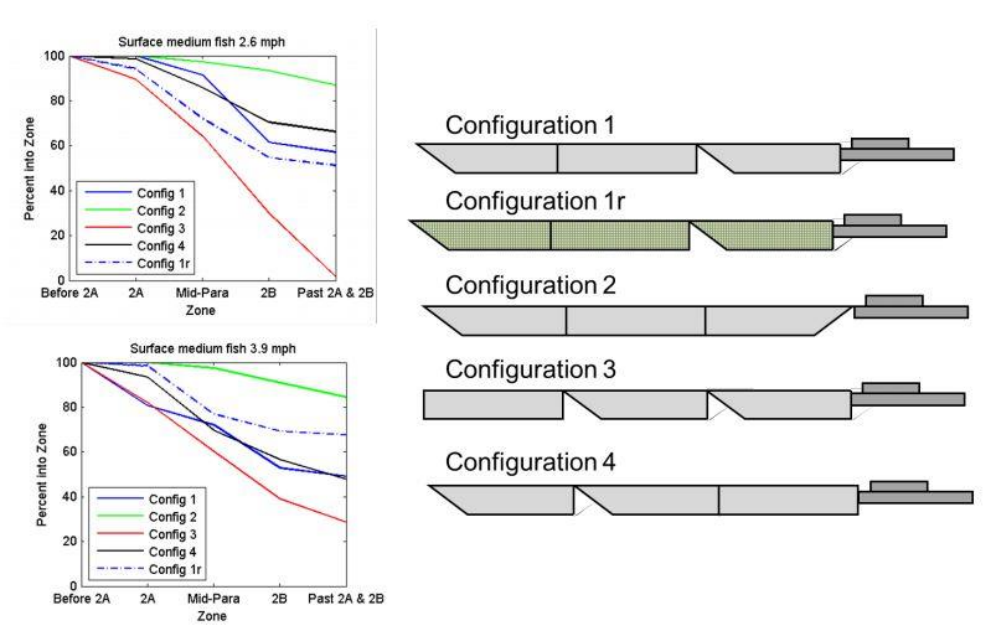

Figure 4. Percentages of model fish carried beyond the model Barrier IIA (2A), the middle parasitic structure (Mid-Para Zone), Barrier IIB (2B), and beyond all of the structures for both barriers (Past 2A & 2B). Note 1r utilized barges with "roughened" bottoms to more accurately represent barge tows transiting the electric barrier. Figure created by ERDC-CHL.

Source: Summary of Fish-Barge Interaction Research and Fixed Dual Frequency Sonar (DIDSON) Sampling at the Electric Dispersal Barrier in Chicago Ship Canal

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Introduction - Alternative Technologies

- Sonic – sound
  - Attenuation and habituation
  - Different frequencies affect different species/life stages
- Bubble – High aeration
  - Habituation, feasiblity at large scale
- Light – Strobe
  - Habituation
- Take away? No single non-physical barrier 100% effective
  - More effective when used in combinations
- **What about CO_2?**

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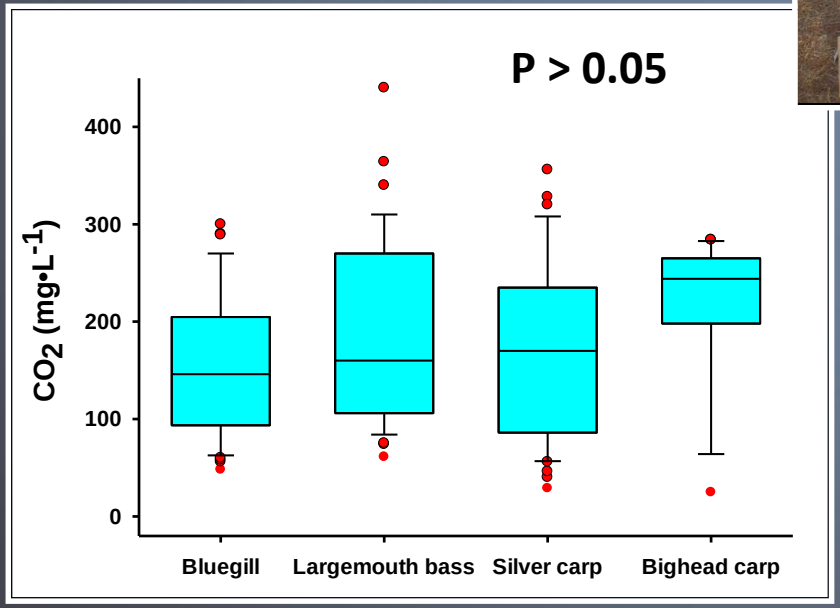
Carbon Dioxide

- Why CO_2?
  - Non-discriminatory
  - Low biological impact
  - Cost-effective?



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Previous Work

- Laboratory Studies
  - Physiological
  - Behavioral

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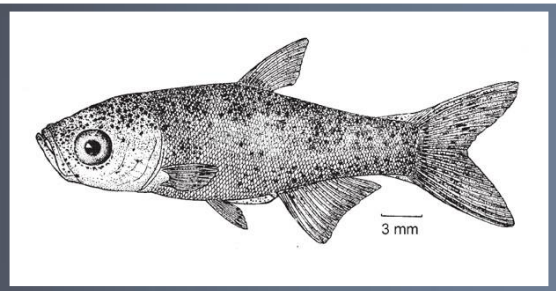
Progress to Date

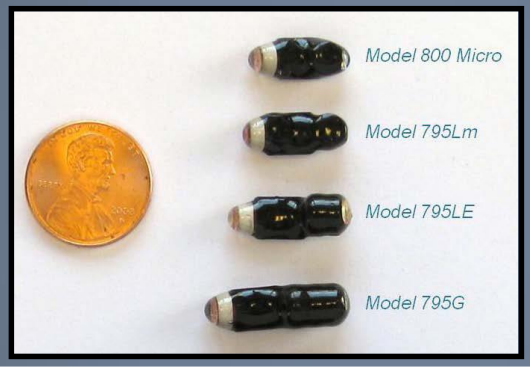


- Early life stage impacts
  - Eggs, larvae, fingerlings
  - Fingerlings do avoid

- Large-scale
  - –Experimental ponds
  - –CO_2 diffusion system
  - –Telemetry

Large-Scale Study

- Experimental ponds
- Multiple fish per trial
- Telemetry



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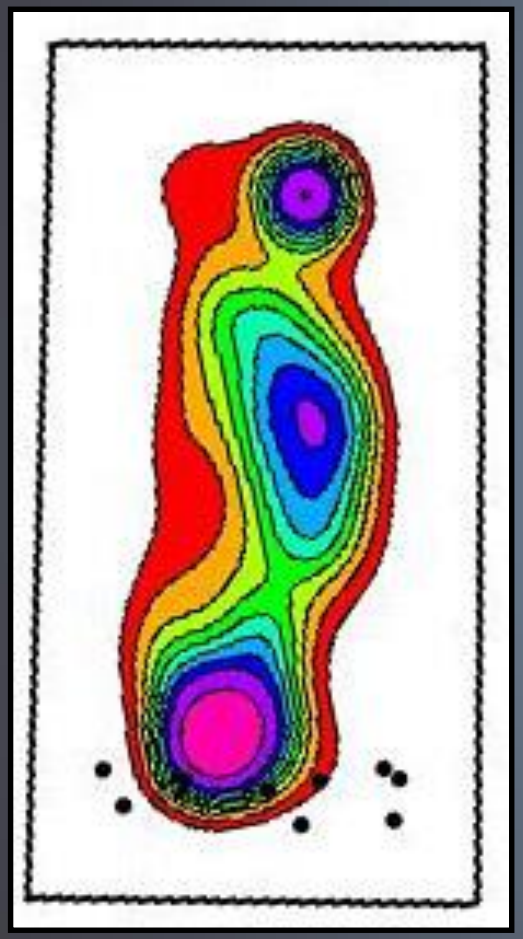
Large-Scale Study - Example Trial



11 hours pre-CO_2
11 am

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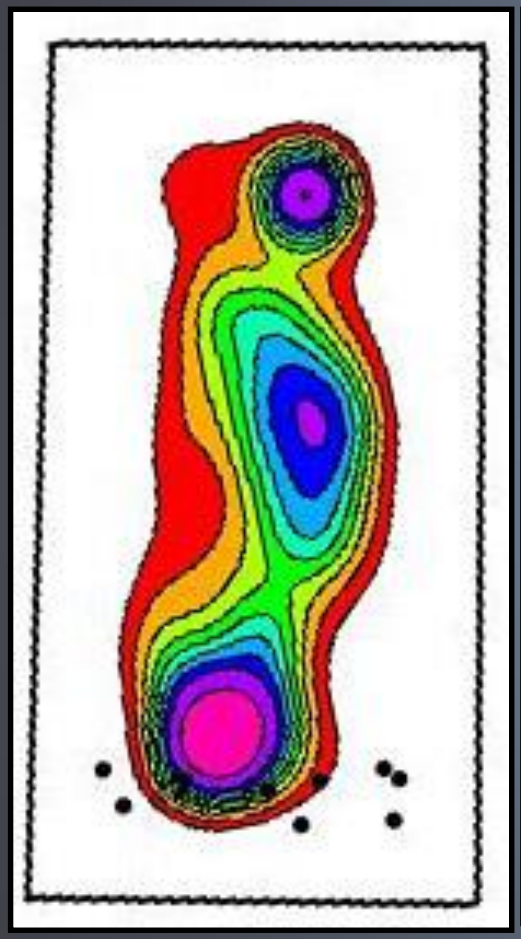
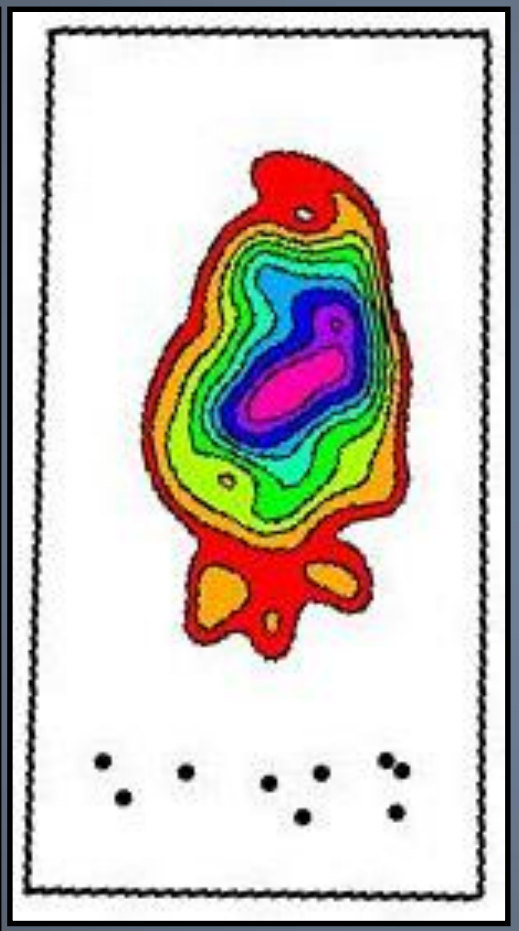
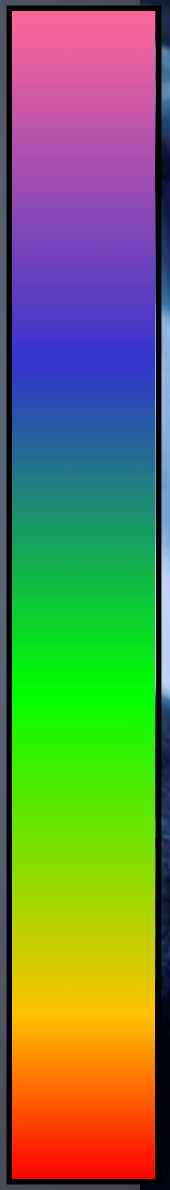
Large-Scale Study - Example Trial



11 hours pre-CO_2
11 am



11 hours post-CO_2
8 am



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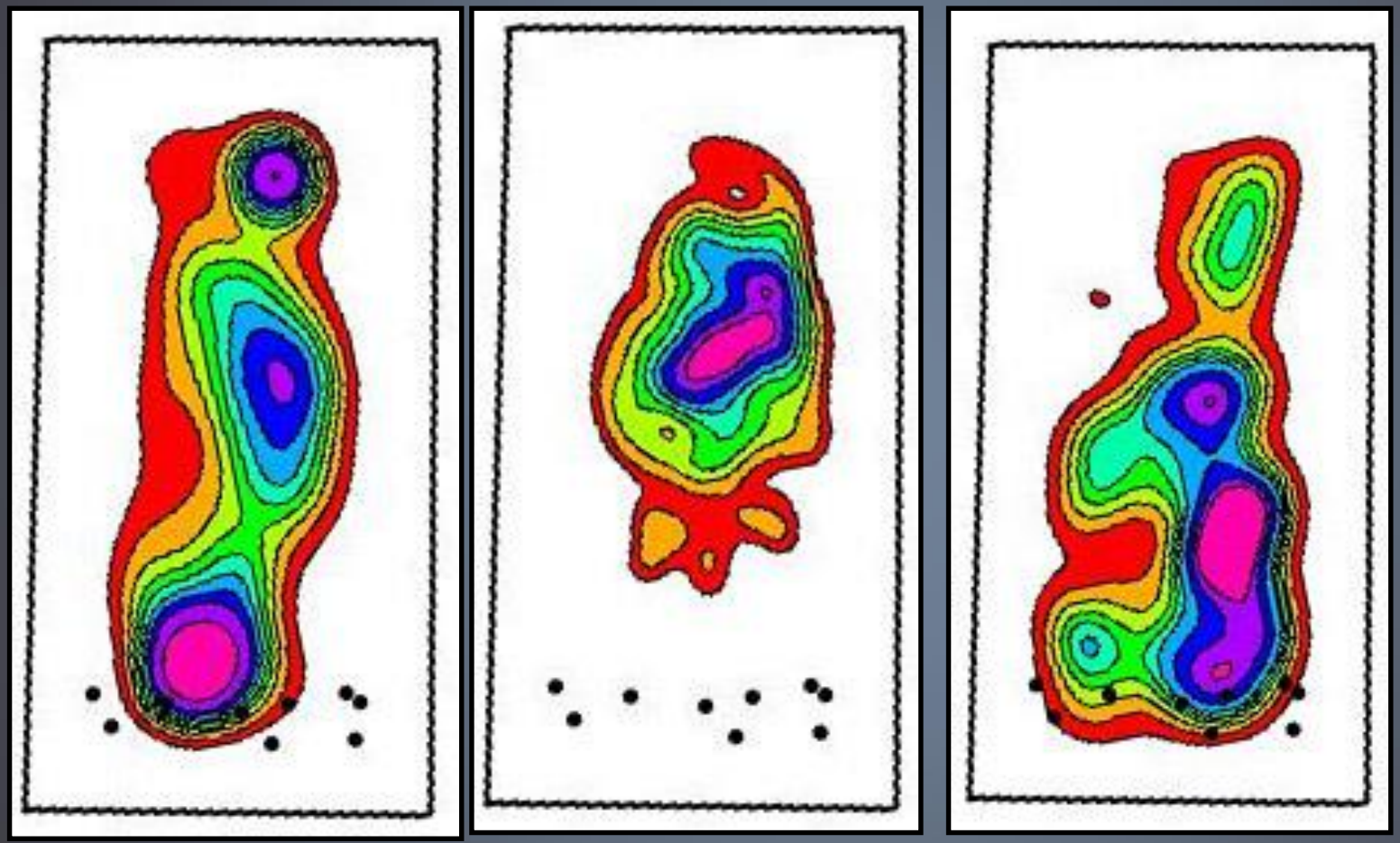
Large-Scale Study - Example Trial



Highest Fish Density

Lowest Fish Density

11 hours pre-CO_2
11 am

11 hours post-CO_2
8 am

20 hours post-CO_2
5 pm

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Large-Scale Study - Conclusions

- Additions of CO_2 successfully influenced the movement and distribution of free-swimming fish
  - Lower concentrations than in the lab (~70-120 mg/L vs 150-210 mg/L)
- Application occurred at 'medium' scale
  - Earthen pond
  - 1.6 million gallons
- CO_2 remained stable over extended periods
- Native species impacted in similar manner

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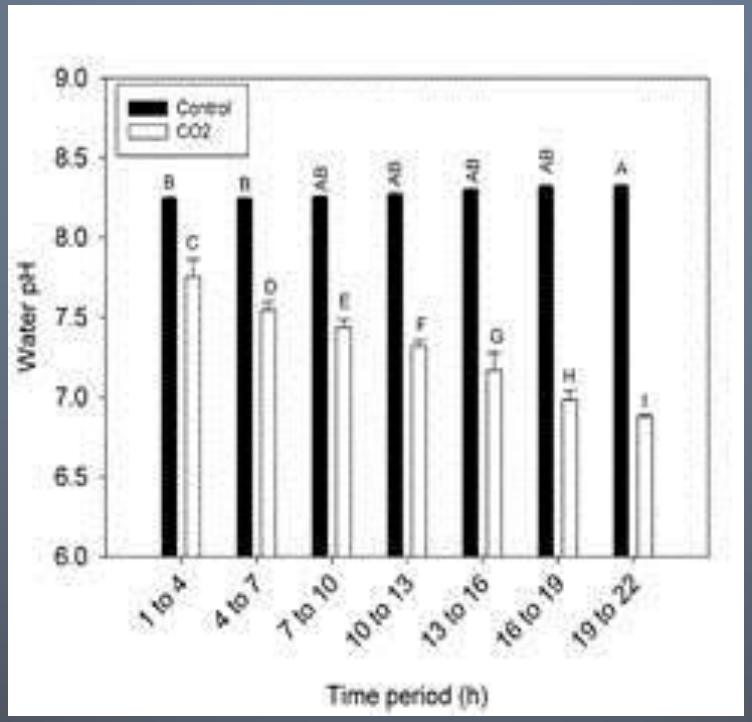
CO_2 and pH Relationship

- $CO_2 + H_20 \leftrightarrow H_2CO_3$

- Alkalinity – buffering capacity (ability to neutralize an acid)



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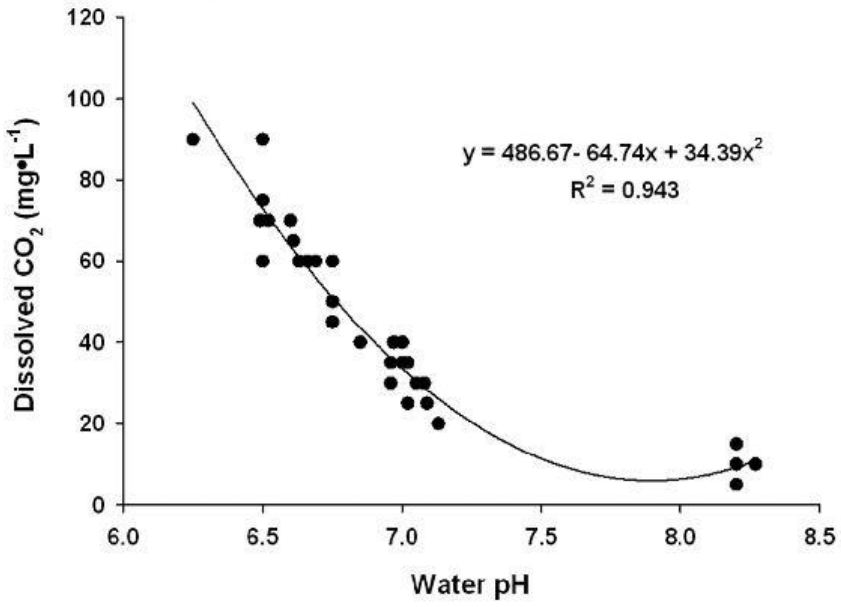
CO_2 and pH - Previous Studies

Fig. 1. Relationship between water pH and dissolved CO_2 ($mg \cdot L^{-1}$) concentration in the water. Measurements were collected during experimental trials. Equation of the line is given on the figure.



Kates et al. 2012_CJFAS

Dennis et al. 2014_*in press*

Location	Species	Life Stage	Final Temp (°C)	Final Dissolved Oxygen (mg/L)	Final pH	Final Total Alkalinity (mg/L)	Final dissolved CO2 (mg/L)	Final pCO2 (µatm)
Osage Beach, MO	BHC SLC	Fry	24.8 ± 0.01	7.6 ± 0.02	C1 – 8.13 ± 0.03	C1 – 246 ± 3	C1 – 40 ± 1	C1 – 2454 ± 170
					C2 – 8.16 ± 0.01	C2 – 244 ± 4	C2 – 40 ± 1	C2 – 2177 ± 55
					L1 – 7.45 ± 0.02	L1 – 242 ± 2	L1 – 77 ± 1	L1 – 11499 ± 545
					L2 – 7.39 ± 0.01	L2 – 241 ± 3	L2 – 74 ± 0.4	L2 – 13100 ± 373
					H1 – 6.88 ± 0.01	H1 – 243 ± 3	H1 – 123 ± 2	H1 – 42266 ± 460
					H2 – 6.86 ± 0.01	H2 – 241 ± 3	H2 – 123 ± 1	H2 – 43567 ± 400
Urbana, IL	LMB BLG	Juveniles	17.0 ± 0.1	8.9 ± 0.05	C1 – 8.28 ± 0.02	C1 – 148 ± 2	C1 – 15 ± 0.2	C1 – 919 ± 40
					C2 – 8.26 ± 0.01	C2 – 147 ± 2	C2 – 15 ± 0.2	C2 – 961 ± 40
					L1 – 6.64 ± 0.01	L1 – 153 ± 2	L1 – 74 ± 1	L1 – 41827 ± 939
					L2 – 6.64 ± 0.01	L2 – 159 ± 2	L2 – 73 ± 1	L2 – 43181 ± 1134
					H1 – 6.45 ± 0.01	H1 – 145 ± 3	H1 – 112 ± 1	H1 – 61967 ± 2241
					H2 – 6.44 ± 0.01	H2 – 150 ± 2	H2 – 115 ± 1	H2 – 65370 ± 1734
La Crosse, WI	SLC BHC	Juveniles	16.0 ± 0.03	8.4 ± 0.04	C1 – 8.37 ± 0.02	C1 – 156 ± 3	C1 – 15 ± 1	C1 – 782 ± 26
					C2 – 8.38 ± 0.01	C2 – 153 ± 3	C2 – 15 ± 1	C2 – 747 ± 22
					L1 – 6.41 ± 0.01	L1 – 161 ± 3	L1 – 72 ± 1	L1 – 73127 ± 1243
					L2 – 6.41 ± 0.01	L2 – 162 ± 2	L2 – 70 ± 1	L2 – 74270 ± 1023
					H1 – 6.00 ± 0.01	H1 – 161 ± 2	H1 – 122 ± 1	H1 – 188993 ± 2745
					H2 – 6.02 ± 0.01	H2 – 166 ± 1	H2 – 120 ± 1	H2 – 186435 ± 2978

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Lessons Learned

- Zone of elevated CO_2 has potential to act as a non-physical barrier
  - Activate stress response of larval, juvenile, and adult fishes
  - Juvenile and adult fishes avoid CO_2 areas
  - Free swimming fish will avoid CO_2
  - Not size specific or species specific
- Easy to deploy
- Carbon dioxide barrier trials in the field
- Non-target impacts need to be quantified

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Next Steps

- *In situ* application
- Great Lakes Commission
  - Response to GLMRIS
  - Proposed solution
  - Less costly

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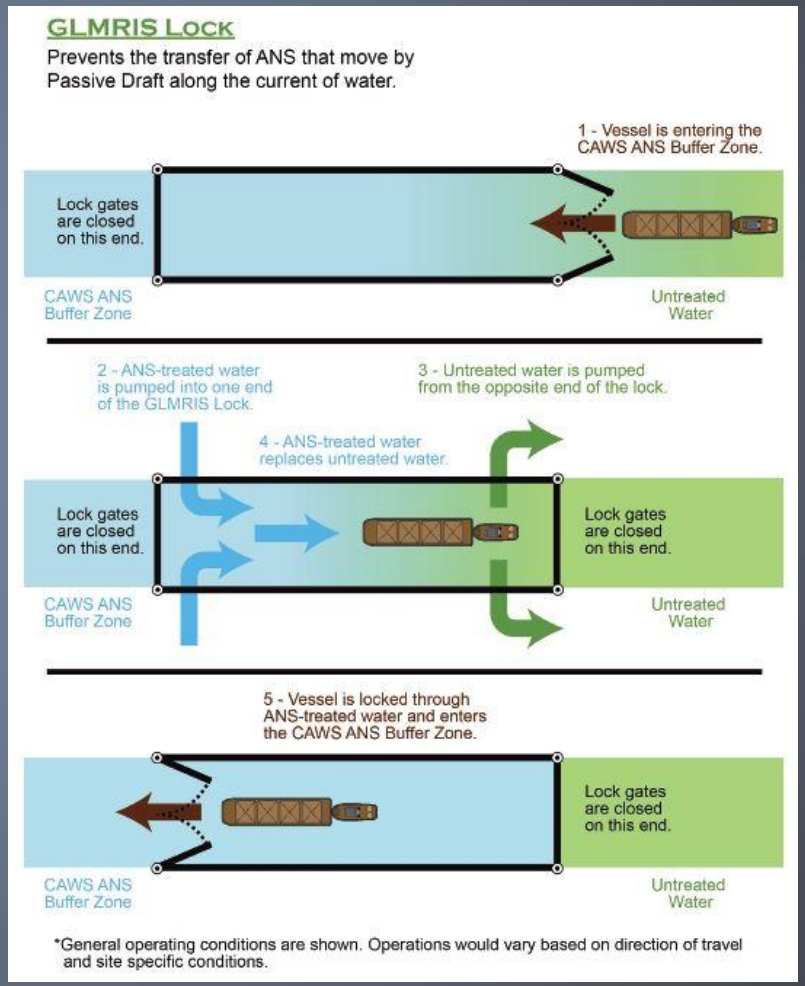
Next Steps - GLMRIS Lock

- Oneway ANS lock
- Modified GLMRIS Lock
- Testing grounds for alternative technologies
  - Sonic, bubble, CO_2, light



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Great Lakes Commission
des Grands Lacs

Great Lakes and St Lawrence Cities Initiative
Alliance des villes des Grands Lacs et du Saint-Laurent

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