

Potential Effects of Coalbed Natural Gas Produced Waters on Aquatic Life

by

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MALE



FEMALE



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History

- **Toxicity Identification Evaluation by Boelter et al. 1992 determined salinity as primary toxicant in oil field discharge**
- **Mount et al. 1997 used zooplankton and fathead minnows to predict toxicity of salinity**
- **Water quality standards do not currently exist for NaHCO_3**

METHODS - ACUTE

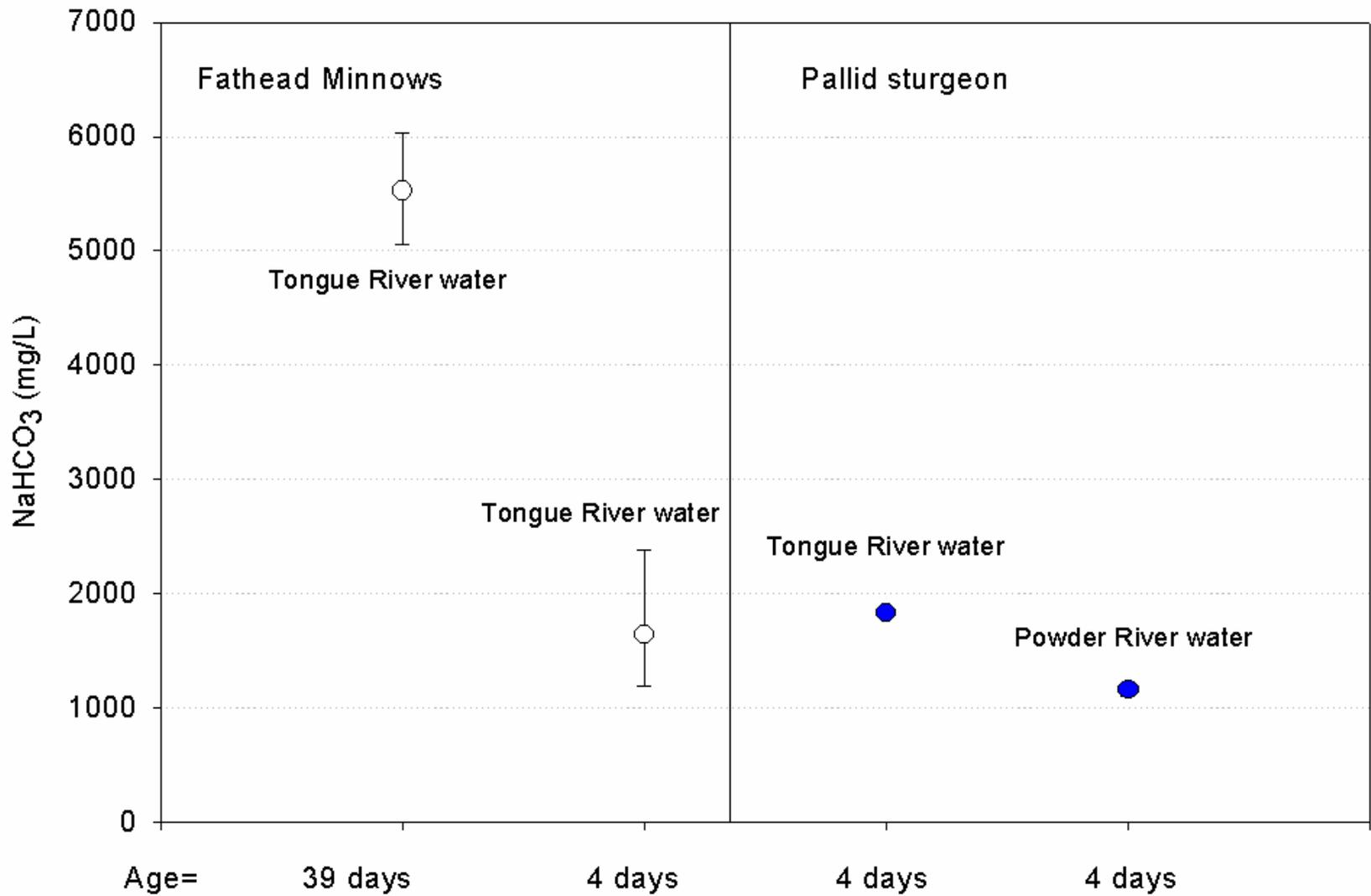
- **Tongue or Powder**
River simulated
- **FHM, White**
Sucker, Pallid
Sturgeon
- **96 hr experiments**
- **LC50 calculated**



RESULTS – ACUTE EXPERIMENTS

Species	Age of fish in days (post-hatch)	Water being simulated	Sodium bicarbonate LC50, mean, mg/L (95% CI)
Fathead Minnow	4 days	Powder River	1,643 (1,188-2,377)
Fathead minnow	4 days	Tongue River	>4,000
Fathead minnow	39 days	Tongue River	5,526 (5,057-6,038)
White sucker	22 days	Tongue River	5,121 (4,049-6,678)
White sucker	22 days	Powder River	5,421
Pallid sturgeon	4 days	Powder River	1,158 (1,103-1,216)
Pallid sturgeon	4 days	Tongue River	1,828

96-h LC50 values (\pm 95% CI)



METHODS - CHRONIC

- **Three chronic experiments performed**
- **Two with FHM and one with white sucker**
- **NaHCO₃ added in varied concentrations**
- **Fish exposed from fertilization to 43 or 60 days post-hatch**
- **Laboratory water simulated Tongue River**

Water Chemistry - Chronic

- **Daily - Conductivity, dissolved oxygen, and temperature**
- **Weekly - pH, hardness, alkalinity, major ions (Na, K, Ca)**



RESULTS - CHRONIC

Fathead Minnow Experiment 1 % Survival				Fathead Minnow Experiment 2 % Survival			
Treatment	96-h	0-30-d	30-60-d	Treatment	96-h	0-30-d	30-60-d
Control	94	89	96	Control	90	67	99
500	83	64*	93	300	93	35	100
800	55	33*	+	400	90	57	100
1100	40	21*	+	625	60	30*	100
1400	8	2*	+	-----	----	----	----

***=P<0.05**

+Sacrificed concentrations on Day 37

RESULTS – CHRONIC



White Sucker % Survival

Treatment	96-h	0-25-d	25-43-d
Control	64	54	69
450	84	80	72
800	90	53	82
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1400	94	52	45

Methods – In Situ

- **Two 96 hr experiments**
 - **Experiment 1, 2 day old FHM at 6 sites (two reference sites)**
 - **Experiment 2, 6 day old (6 d) FHM at 4 sites**
- **Alk, Cond, DO, pH, temp, monitored daily at all sites.**
- **Cond, DO, pH, temp monitored hourly at four sites.**
- **Water samples collected cation and anions**
- **Survival monitored daily**



Burger Draw



Lower Beaver

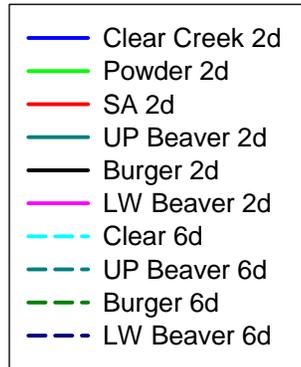
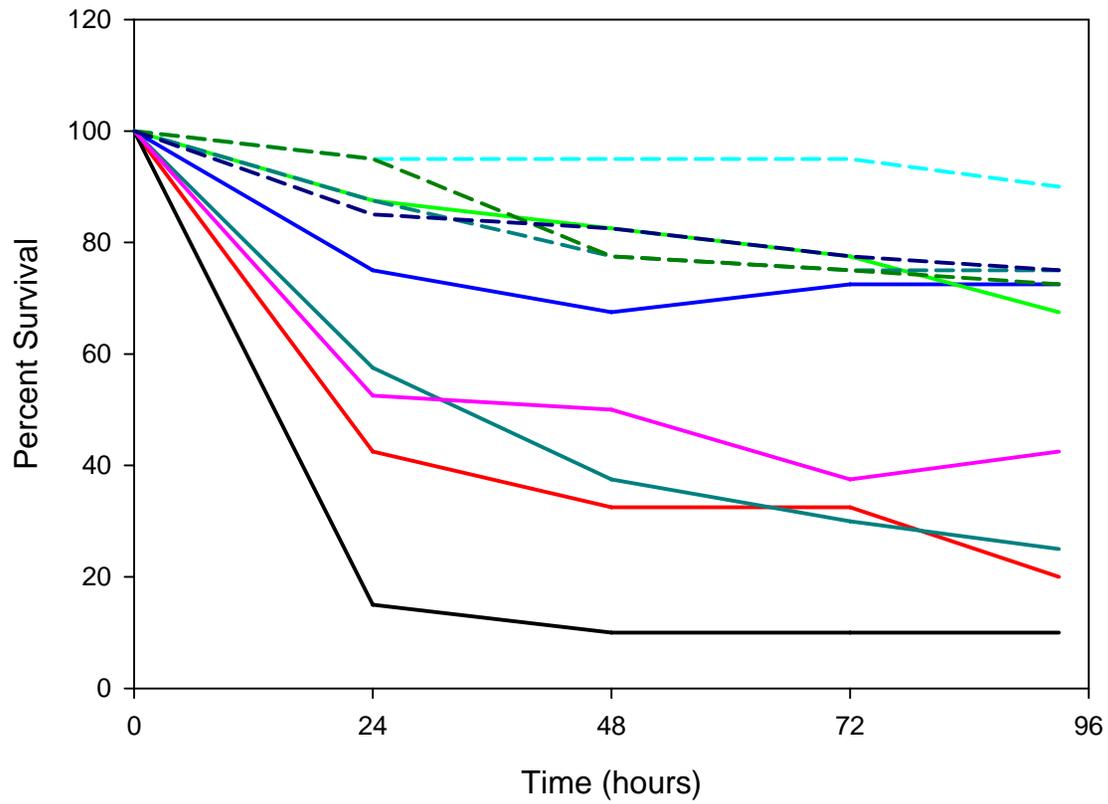


In-situ containers

Percent Survival

Site Name	Age at start	% Survival at 96 h
Experiment 1:		
PR @ Moorhead	2 day	77
Clear Creek	2 day	78
Pooled Reference		78
SA Creek	2 day	24*
Upper Beaver	2 day	37*
Lower Beaver	2 day	49*
Burger Draw	2 day	11*
Experiment 2:		
Clear Creek	6 day	90
Upper Beaver	6 day	75
Lower Beaver	6 day	75
Burger Draw	6 day	73

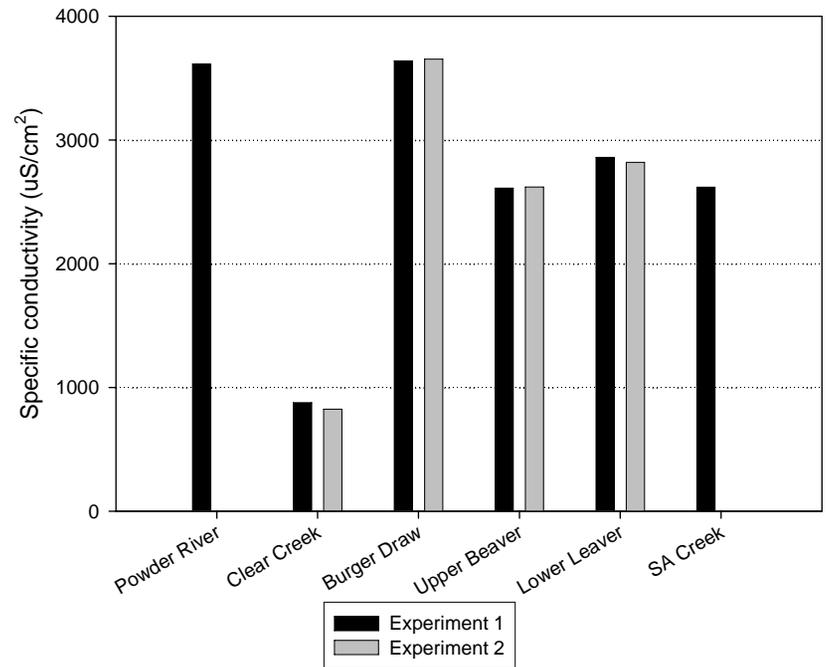
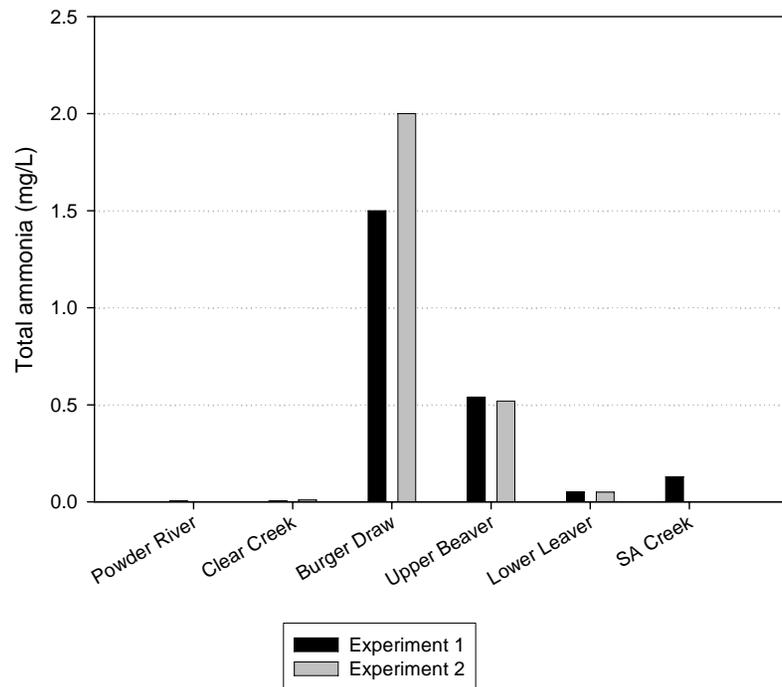
* Significant difference from Pooled Reference at $P > 0.05$



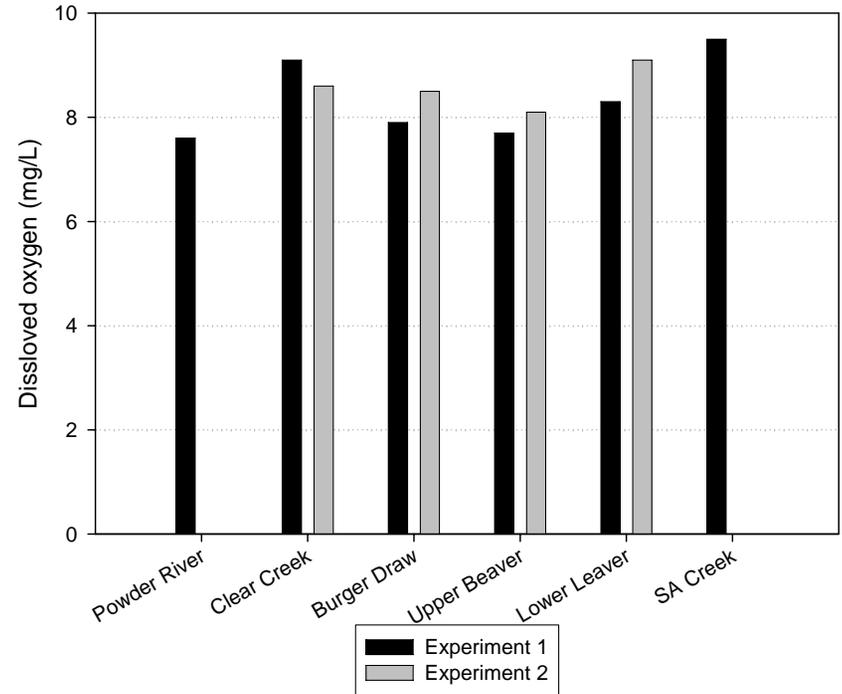
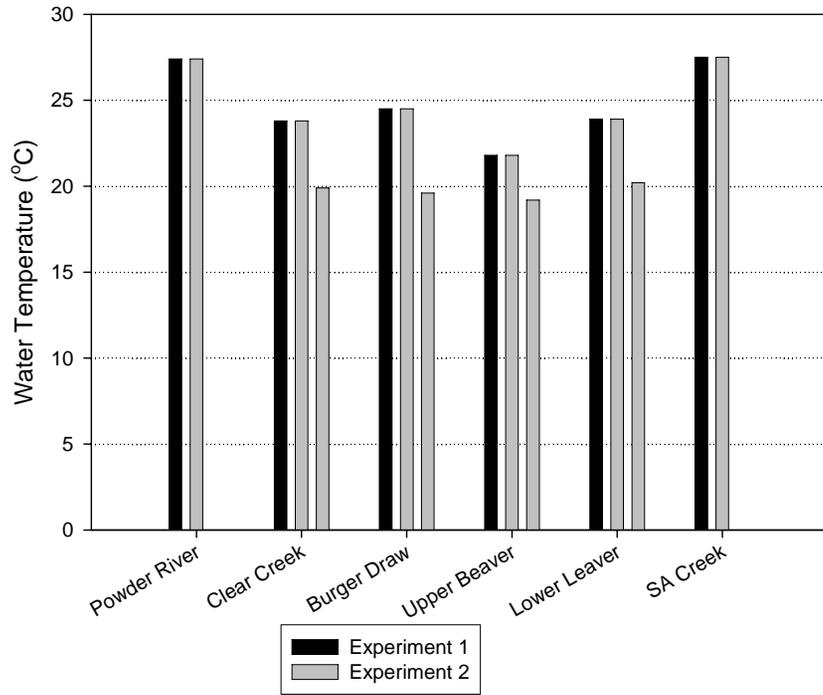


**HEY,
WHY ARE
FISH HERE?**

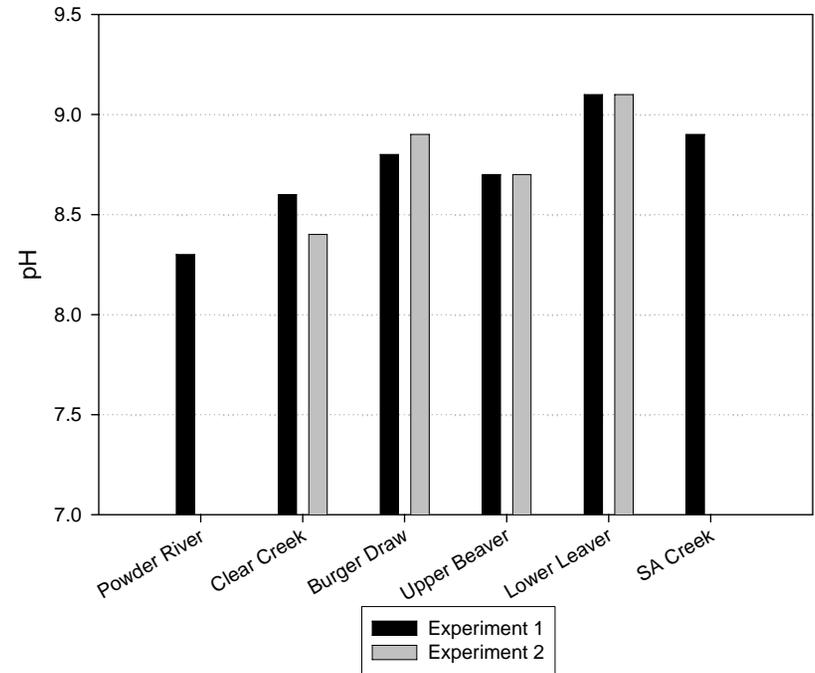
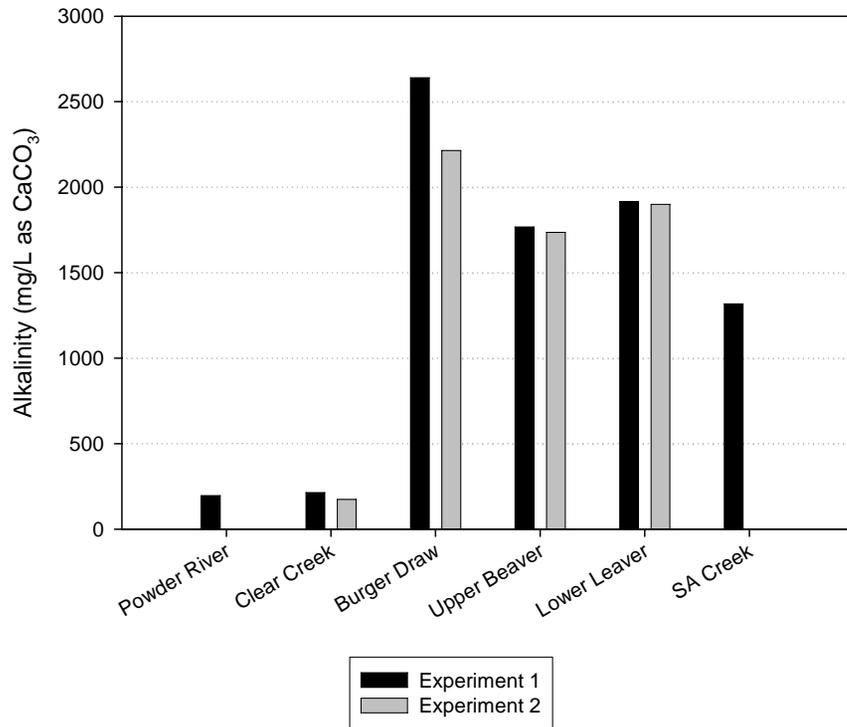
Ammonia and Conductivity



Temperature and Dissolve O₂



Alkalinity and pH



Results

- **As predicted by the laboratory experiments, the age of FHM at initiation of experiment affects toxicity**
- **Significant effects on survival of 2 day old fish observed at all sites investigated**
- **Ammonia was not likely a factor at SA Creek and Lower Beaver**

Future Plans

- **Complete measurements of cations and anions on water samples to especially define the Na concentrations**
- **Perform additional in-situ experiments with sturgeon or another suitable species in Summer '07**
- **Perform additional laboratory acute and chronic experiments with fish, ceriodaphnia and amphibians, spring '07**



