

Assessing the effects of wastewater treatment plant effluents on freshwater mussels: ammonia data

Serena Ciparis

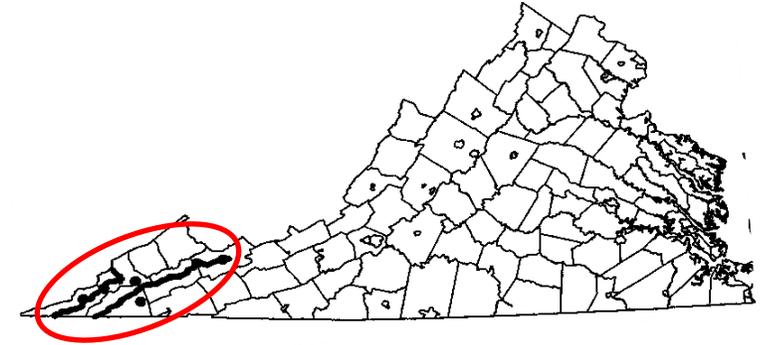
&

Susan Lingenfelter



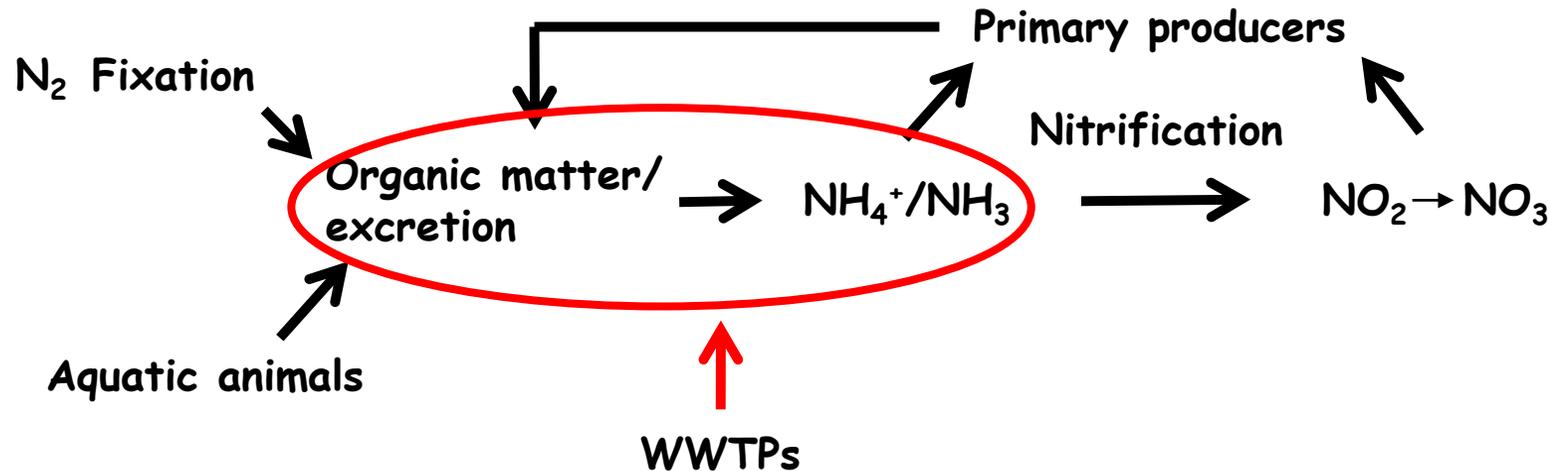
Clinch River and Powell River watersheds

- **Supports species-rich assemblage of fish and freshwater mussels (>150 species)**
 - High concentration of rare and endangered species
- **Status of freshwater mussel populations – imperiled**
 - Historic – precipitous declines
 - Current - some areas have stable populations, other areas in decline
 - Exact cause is unknown
- **Stressors in the basin**
 - Active surface mining operations – mountaintop removal (MTM)
 - Abandoned deep mines
 - Agriculture
 - WWTPs (38 municipal discharges)



Freshwater mussels

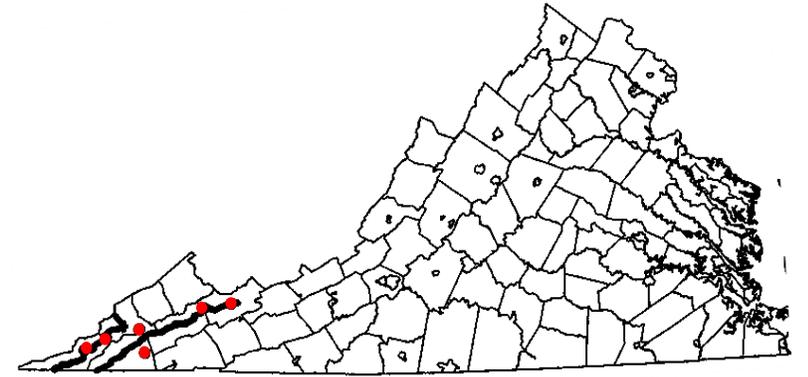
- Generally sensitive to contaminants
 - Majority of studies have focused on survival and growth
- Highly sensitive to ammonia (NH_3) – most sensitive taxon



- **Objective 1:**
 - *To assess the effects of WWTPs on water quality, sediment chemistry, and freshwater mussels within the context of watershed land use*

Study design

Site	% For	% Devel	% Ag	% Mine	WWTP MGD
Ag_1	50	10	40	<1	>1
Ag_2	66	11	23	<1	>1
Ag_3	44	6	50	0	<1
M_1	65	16	12	7	>1
M_2	77	8	3	12	<1
M_3	79	9	<1	11	>1



- 6 sites selected
- Each site - sampling locations upstream and downstream of a WWTP discharge
- 3 sites - mining in the watershed
- 3 sites – relatively 'high' agriculture

- **Mussels (*Lampsilis fasciola*) deployed for 8 weeks**
 - August – October (low flow)
 - In mixing zone (~ 10 m from discharge)



10 mussels/silo



3 silos

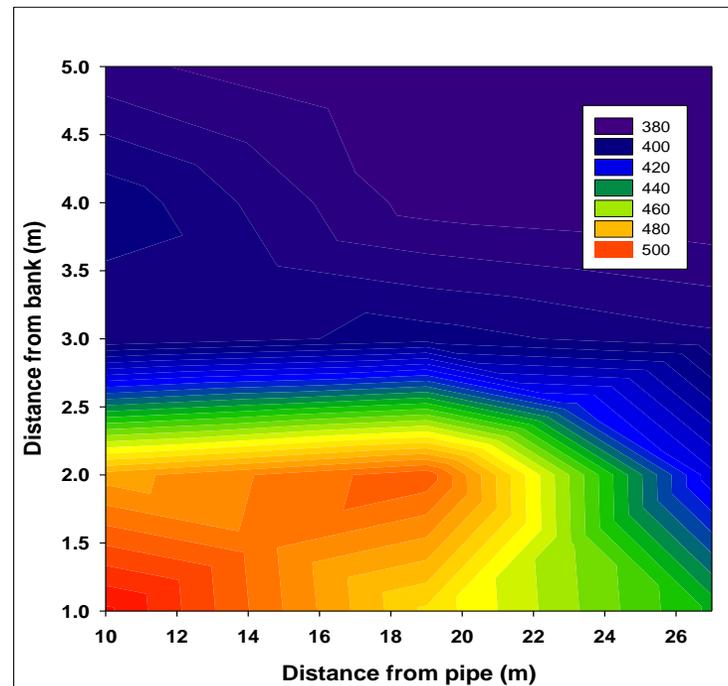


Above and below

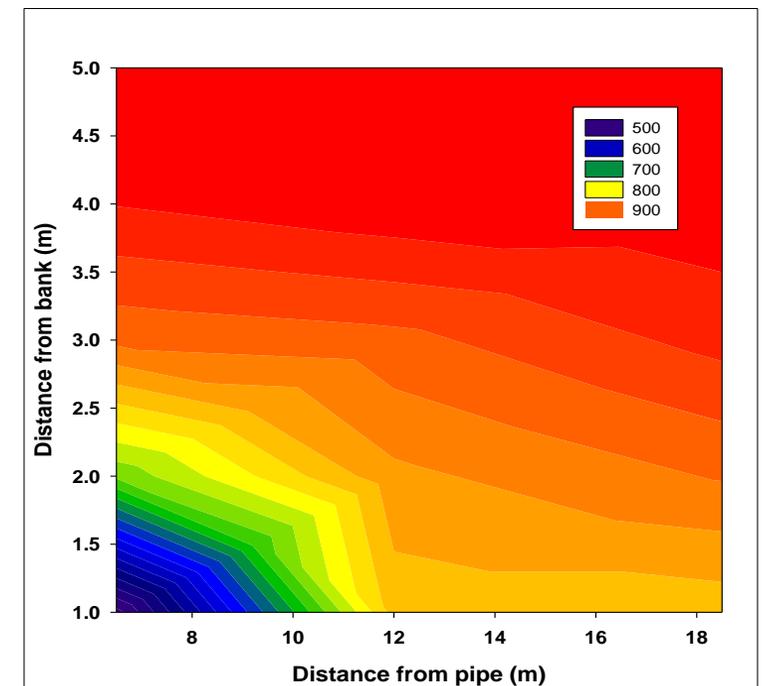
Methods: water sampling

- 'Plume mapping' – specific conductivity measurements
 - Intervals: downstream & bank to bank
- Grab samples in Aug., Sept. & Oct.
 - $\text{NH}_3\text{-N}$, $\text{NO}_3\text{-N}$, total Kjeldahl N, total P, SO_4^{2-} , Cl^-
- Discharge

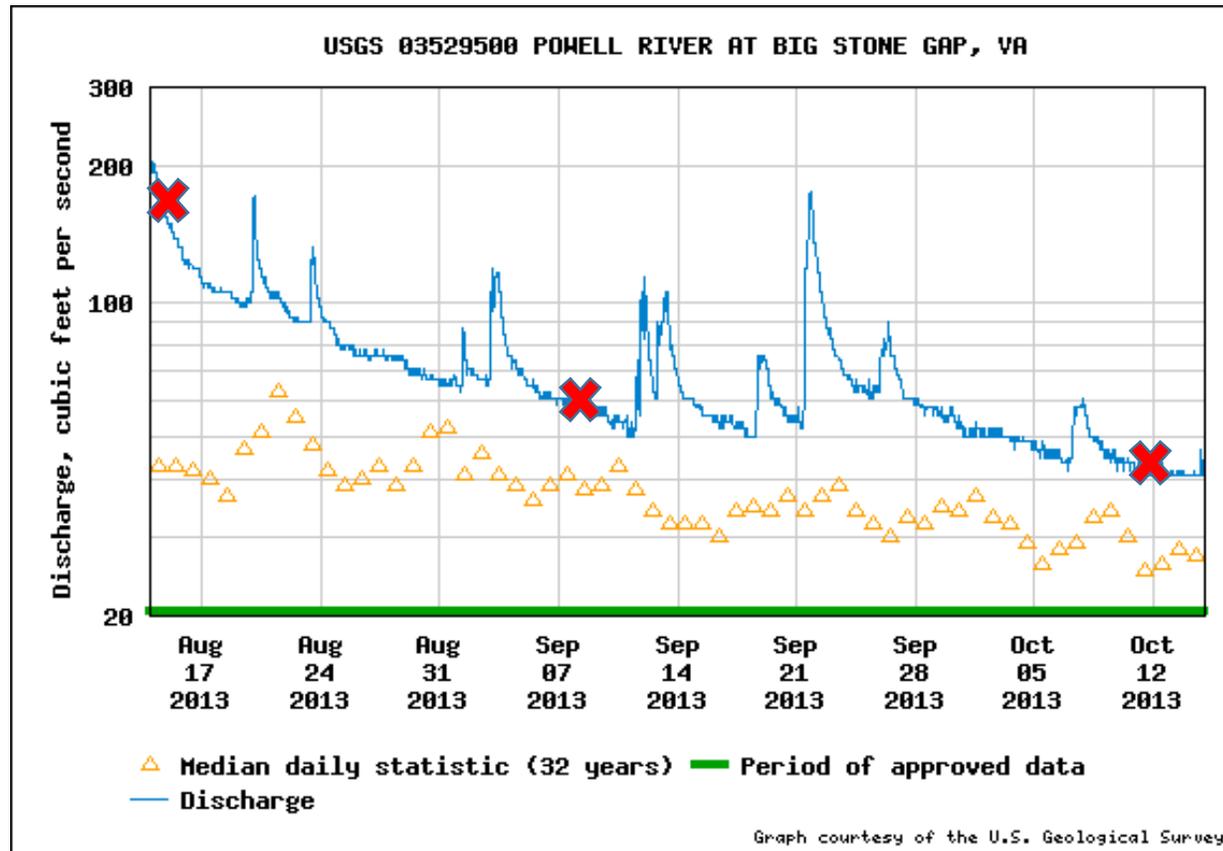
Agriculture – downstream $\mu\text{S/cm}$



Mining – downstream $\mu\text{S/cm}$



Sampling conditions



- **Temperature**

- **Aug: 16.9 - 20.4 °C**
- **Sept: 18.6 - 22.5 °C**
- **Oct: 13.9 - 20.1 °C**

- **pH**

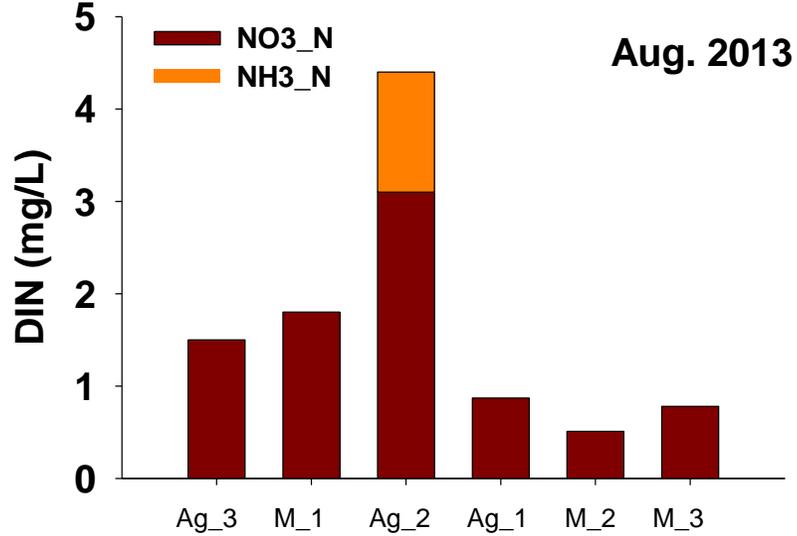
- **Aug: 7.49 - 8.35**
- **Sept: 7.44 - 8.26**
- **Oct: 7.21 - 8.22**

Results: ammonia

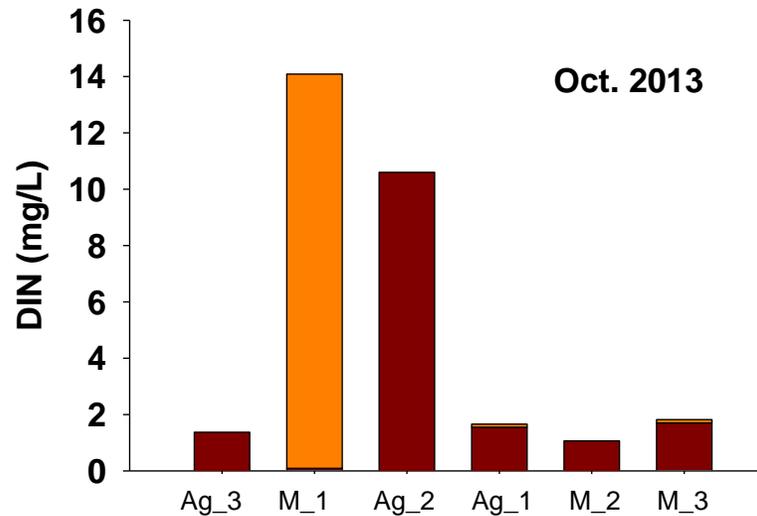
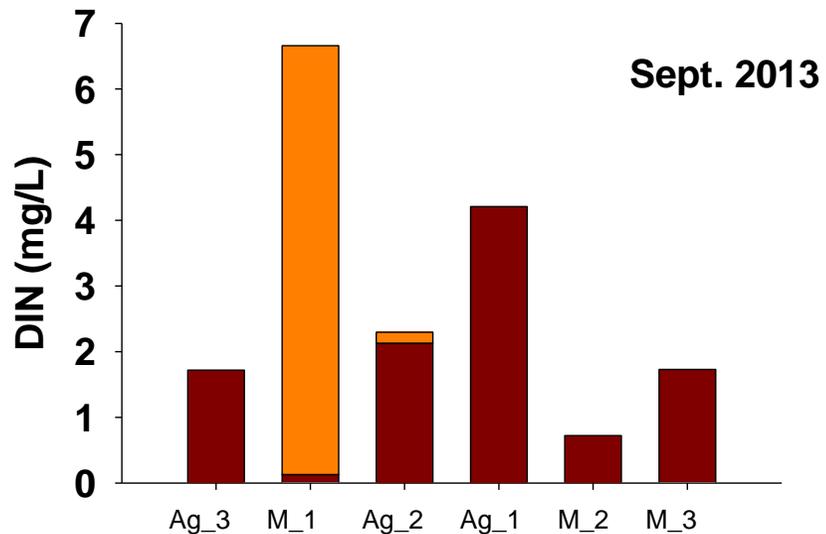
- Of 36 samples, only 10 had NH₃-N concentrations >0.1 mg/L (QL)
- Concentrations in 3 samples exceeded USEPA 2013 criteria

Site	Event	Position	NH ₃ -N (mg/L)	Acute (mg/L)	Chronic (mg/L)
M_1	Sept.	DS	6.5	9.74	1.44
M_1	Oct.	DS	14	13.97	1.84
Ag_1	Oct.	UP	0.15	11.55	1.68
Ag_1	Oct.	DS	0.11	6.03	1.08
Ag_2	Aug.	DS	1.3	6.93	1.18
Ag_2	Sept.	UP	0.11	4.09	0.8
Ag_2	Sept.	DS	0.17	5.10	0.94
Ag_2	Oct.	UP	0.11	6.76	1.16
M_2	Oct.	UP	0.10	13.48	2.08
M_3	Oct.	DS	0.12	3.37	0.69

Results: DIN



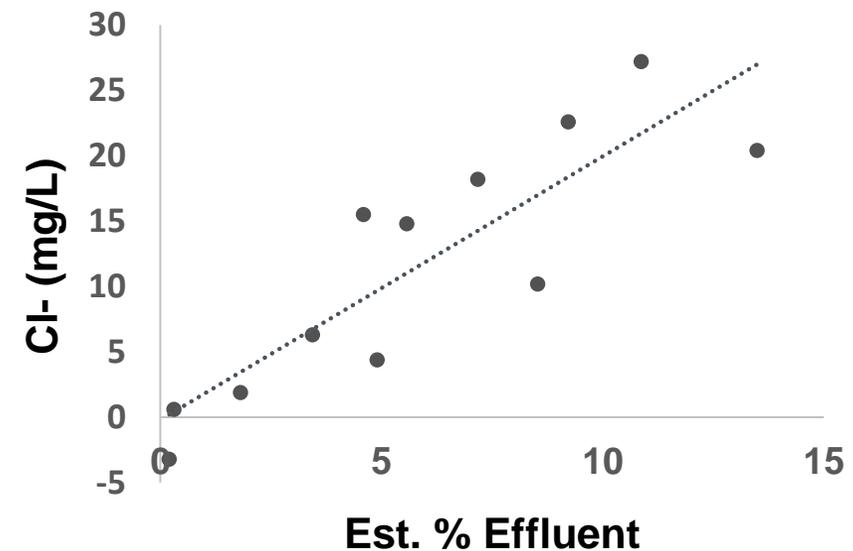
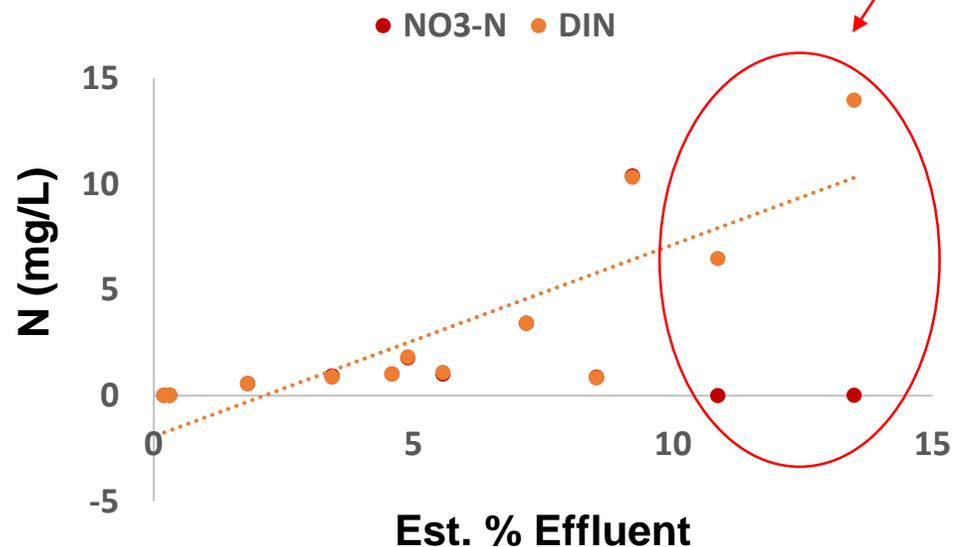
- Majority of N as NO₃-N downstream of WWTPs (one exception)
- Little to no contribution of organic N



WWTP contributions

- Concentration difference (downstream – upstream) vs. estimated % effluent at baseflow
 - Effluents contribute a proportional amount of N

- Site with highest % effluent - elevated $\text{NH}_3\text{-N}$
 - Estimated mean loading = 67 kg/d $\text{NH}_3\text{-N}$
 - Toxicity observed downstream



Nitrification?

Site	Event	NH ₃ -N (mg/L)	Avg. @ WWTP (mg/L)	Max. @ WWTP (mg/L)	"Pipe Type"
Ag_1	Aug.	<0.1	3.5	9.3	Rock cascade
Ag_1	Sept/Oct	0.11	<QL	0.63	
M_3	Aug.	<0.1	0.8	2.8	Rock cascade
M_3	Sept/Oct	0.12	0.3	1.3	
Ag_2	Aug.	1.3	0.46	1.5	Elevated pipe
Ag_2	Sept/Oct	0.17	<QL	<QL	
Ag_3	Aug.	<0.1	12	12	Elevated pipe
Ag_3	Sept/Oct	<0.1	<QL	<QL	
M_1	Aug.	<0.1	-	-	Cement structure
M_1	Sept/Oct	10.27	-	-	
M_2	Aug.	<0.1	<QL	<QL	Cement structure
M_2	Sept/Oct	0.1	<QL	<QL	

Conclusions

- **High ammonia concentrations do not appear to be a universal problem in the Clinch-Powell system (limited sampling)**
- **However, loadings from 'problematic' WWTPs may be an issue further downstream**
- **Similar situations are likely in other basins**
- **Nitrification may occur from the pipe to the receiving stream**
 - **Dependent on type of outfall?**



Further study

- **Comparison of in-pipe vs. in-stream measurements**
 - **Simultaneous sampling – does nitrification occur?**
 - **Seasonal effect?**
- **Effect of outfall type**
 - **Are there cost effective solutions for reducing ammonia?**
- **Feasibility for incorporation of in-stream measurements into future application of WQS**

'Overlap' of endangered mussel habitat & WWTPs

