Effects of salinity derived from road salt and total suspended solids on yellow perch eggs and larvae from two Chesapeake Bay tributaries.

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ABSTRACT

Yellow perch (*Perca flavescens*) have historically been a major commercial and recreational fishery in the Chesapeake Bay watershed. A semi-anadromous species, it lives in fresh to brackish waters of many Chesapeake Bay tributaries, and migrates to upstream freshwater habitats to spawn. The primary movements are the upstream spawning migration of adults and the downstream dispersal of juveniles. Although Bay tributaries like the Choptank have healthy populations of yellow perch, with no indication of egg/larval viability problems, Severn River populations are doing poorly with evidence of depressed egg and larval viability. Two of the potential causes are elevated salinity and total suspended solids (TSS). The goal of this study is to analyze the impacts of salinity (ambient estuarine and road salt adjusted well water) and exposure to suspended sediments on the survival of yellow perch eggs and larvae from two rivers, the Severn and the Choptank. Adult yellow perch were collected and spawned in a hatchery and fertilized eggs were transported to the test facility. Year one of this study looked at the effect of salinity. Eggs and larvae from the Severn and Choptank Rivers were maintained at three salinities (1.5, 3 and 6‰ derived from well water diluted estuarine water or road salt in well water), Severn River water (1‰), or well water as a control. Eggs were tested until hatch out (approximately 2 weeks), while larvae were tested for 5-7 days. Water samples were analyzed for dissolved metals, cations, and anions. Percent hatch, time to hatch, survival and abnormality data was collected from eggs, while survival and abnormality data were analyzed for larvae. No survival effects were observed for either Choptank or Severn larvae when exposed to elevated salinities. Although final hatch out of eggs was unaffected, the time to hatch and number of malformations increased in eggs from both rivers in 6‰ road salt; and for Severn River eggs only in 6‰ estuarine water. Interestingly, time to hatch was also increased for both egg types exposed to Severn River water samples at 1‰. Metals, cations and anions concentrations in test water were compared to levels in ambient samples collected from the Severn River during rain events in different seasons.

Statistical Analyses

- Mortality data were analyzed with the computer program TOXSTAT v. 3.5 (West, Inc. Western Ecosystem Technology, Cheyenne, WY).
- Datasets were tested for normality (Shapiro-Wilk's test) and homogeneity of variance (Bartlett's Test).
- Fish abnormality data were statistically analyzed with a Fisher exact probability test.
- An α of 0.05 was used for all probability testing.

Materials and Methods

Water Sampling

- An ISCO sampler was set up in the previously established yellow perch spawning range of the Severn River and triggered prior to rain events. Samples were collected every 4 h for 4 consecutive days.
- Samples were analyzed for conductivity, metals (Cr, Mn, Co, Ni, Cu, Zn, Cd, and Pb), cations (Na, K, Mg and Ca), anions (F, Cl, Br, NO_3-N, PO_4, and SO_4), as well as an ASTM spot test for Cyanide.

Embryos and Larval Fish

- Prespawn adult yellow perch were collected from the Severn and Choptank Rivers, spawned at the hatchery, and resulting egg chains delivered for testing.
- Test eggs (separated from egg chain) and larvae were obtained from adult fish from both rivers.

Toxicity Testing

- Road salt was collected from a Maryland Department of Transportation (MDOT) salt dome.
- Three salinities (1.5, 3.0 and 6.0‰) were prepared from road salt in well water or Wye River water with well water.
- Additional treatments were undiluted Severn River water (~1‰) and UV exposed road salt adjusted water (6.0 ‰).

Bioassays

- Test chambers consisted of glass tubing covered on one end with polypropylene mesh.
- Individual test chambers (three per treatment per egg hatch) were hung on the sides of 5 gal fish tanks.
- Exposure was ~ 15 days for eggs and 6 days for larvae.
- Renewals M,W and F.
- Survival, hatching success, time to hatch and spinal malformations were recorded.

Chemical Analysis

- Day 0 water samples were analyzed for conductivity, metals (Cr, Mn, Co, Ni, Cu, Zn, Cd, and Pb), cations (Na, K, Mg and Ca) and anions (F, Cl, Br, NO_3-N, PO_4 and SO_4).
- Salinity was measured with a YSI conductivity meter.

Results

- There was no significant reduction in the number of eggs that hatched by the final test day (Day 14) in any treatment.
- Time to hatch was increased with higher salinities for both egg batches (Severn River and Choptank River) in both the road salt treatment and the Wye River water treatment (Table 1).
- Severn River water (1‰) treatment had the greatest effect on time to hatch (Table 1), despite being at the lowest salinity.
- Larval malformations were also observed (Figure 1), with a statistically significant increase in the number of malformations at the highest road salt concentrations (Table 3).
- Larvae testing revealed no significant difference in survival between any of the treatments and well water control (data not presented).
- Increased ion levels in the Severn River headwaters, potentially due to road salt runoff, were much lower than ion concentrations in toxicity testing (Table 2).
- Exposure of 6‰ road salt treatment to UV light revealed no change in the measured test parameters (data not presented) compared to 6‰ road salt treatment with no UV light exposure.

Day 11 Hatch Out Totals

Egg Source River	Salinity			
	0 ‰	1.5‰	3.0‰	6.0‰
	Well water	Wye River water		
Severn	18.7	13	10*	10.7*
Choptank	15.5	13.3	14	10.7*
	Well water	Well Water with Road Salt		
Severn	18.7	16.7	17	7*
Choptank	15.5	18.5	17	10.7*
	Well water	1 ‰ Severn River Water		
Severn	18.7	7.3*		
Choptank	15.5	4.5*		

Table 1. Average number of eggs hatched (out of 20) by Day 11 after continuous exposure to different salinity waters comprised of Wye River water or road salt in well water. * Significantly different from control. (p=0.05)

Summary of Metals, Cations and Anions Concentrations

	Na	Cl	SO_4	K	Mg	Ca	Cr	Mn	Co	Ni	Cu	Zn	Cd	Pb
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Toxicity test Road Salt 6.0 ‰	**1457**	**1991**	**8.3**	**8.4**	**BDL**	**0.1**	**0.9**	**1.2**	**0.1**	**4.6**	**7.6**	**29.0**	**0.1**	**0.2**
Ambient Severn River														
Spring	**41**	**88**	**18**	**3.6**	**1.9**	**13.0**	**0.7**	**6.4**	**0.35**	**3.3**	**2.6**	**17**	**0.3**	**0.5**
Summer	**214**	**719**	**62**	**13.7**	**39.7**	**23.1**	**20.2**	**74.2**	**7.04**	**162**	**39.6**	**395**	**10.1**	**5.4**
Fall	**793**	**1423**	**187**	**14.0**	**81.4**	**20.9**	**10.3**	**164**	**5.3**	**34.7**	**16.7**	**53.6**	**17.6**	**3.3**

Table 2. Metals, cations and anions in Day 0 toxicity test samples and Severn River samples collected seasonally in 2010. Means were calculated using all samples above detection limits.

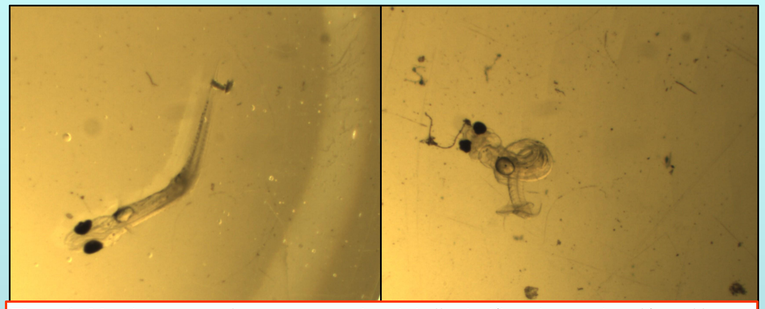

Figure 1. Mutations were moderate to severe. A statistically significant increase in malformed larvae was found after exposing Severn River eggs to 6 ‰ road salt. (Fishers exact probability test; α=0.05)

Number of Malformed Larvae

Well with Road Salt		
Severn River eggs Treatment	**# Mal**	**Total # Hatched**
Well	0	56
1.5‰ RS	0	53
3.0‰ RS	1	58
6.0‰ RS	5*	48
6.0‰ RS w/ UV	6*	54
Severn 1‰	0	51
Choptank River eggs Treatment	**# Mal**	**Total # Hatched**
Well	0	32 (n=40)
1.5‰ RS	0	37 (n=40)
3.0‰ RS	0	58
6.0‰ RS	4	54
Severn 1‰	0	35 (n=40)

Diluted Wye River water		
Severn River eggs Treatment	**# Mal**	**Total # Hatched**
Well	0	56
1.5‰	0	36
3.0‰	0	52
6.0‰	0	55
Choptank River eggs Treatment	**# Mal**	**Total # Hatched**
Well	0	32 (n=40)
1.5‰	0	37 (n=40)
3.0‰	0	37 (n=40)
6.0‰	0	39 (n=40)

Table 3. Number of malformed larvae and final hatch out success (Day 14) after continuous exposure of eggs to different salinity waters comprised of salinity adjusted Wye River water or road salt in well water. Fungus resulted in loss of Choptank egg batches in some treatments (n=40). All others n=60. * Significantly different from control (p=0.05)

Conclusions

- Salinities as high as 6‰, made from either road salt in well water or Wye River water diluted with well water, had no statistically significant effect on final hatch out of yellow perch eggs, or survival of larvae in toxicity tests.
- Hatch out success of eggs by Day 11 revealed several important differences with respect to: egg source (Choptank River versus Severn River), salinity, source of salt (road salt versus Wye River) and river water source (Severn River versus Wye River).
- Although an increase in time to egg hatch was seen in both road salt and Wye River treatments, only the road salt treatments correlated with spinal malformations in larvae; possibly due to the extra time in the egg casing.
- Eggs in both road salt and Wye River treatments at 6‰ corresponded to an increase in time to hatch for both egg types (Severn and Choptank River), suggesting that it is not a component of the road salt, but the salinity increase itself causing the effect.
- Only Severn River eggs had a significant increase in time to hatch in 3‰ Wye River water treatment, suggesting there is another factor involved in differences in time to hatch out. There may be a genetic component, or Choptank River brood stock may have healthier eggs and/or less stressed adults compared to Severn River adults.
- Both egg types (Severn and Choptank River) in Severn River water (1‰) treatment had low Day 11 hatch out, despite being the lowest salinity treatment (Table 1). This suggests there is some other factor, besides elevated salinity and ion concentration, involved in the increase in time to hatch. This may be due to contaminants in runoff coming from the Severn River watershed which has impervious surface cover near 18%.
- Increased ion concentration from road salt is not thought to be a problem in the Severn River because ion levels, potentially due to road salt runoff, were much lower in the ambient Severn River samples than in any of the toxicity tests.
- No cyanide was found in either toxicity tests of UV exposed road salt water or ambient samples from the Severn River. The release of potentially toxic cyanide from road salt does not seem to be a problem.

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