Potential for Contrasting Nutrient Subsidies to Great Lakes Tributaries by Native and Non-native Migratory Fishes

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Background

- Cross-ecosystem subsidies are globally important to aquatic and terrestrial ecosystems (e.g., marine wrack, insect emergences, leaf litter input) (Lamberti et al. 2010)
- In rivers, fish migrations from ocean and lake ecosystems (e.g., Pacific Salmon, Alewife) provide nutrient subsidies that alter stream food webs (Chaloner et al. 2004, Walters et al. 2009)
- The extent of resource subsidy effects is highly context dependent (Janetski et al. 2009), especially with respect to life history and physiological ecology of species involved
- The Great Lakes support >50 migratory fishes with contrasting life histories and the potential to have differential effects on food webs
- Previous studies on nutrient subsidies to Great Lakes tributaries are generally correlative, with no direct measures of excretion and secretion (Burtner et al. 2011, Janetski et al. 2014)

Objective

The purpose of this study was to compare the dynamics of dissolved nutrients excreted and carbon secreted by three Great Lakes fish species – two non-native and one native with contrasting life histories

Approach

- Species studied were non-native Chinook Salmon (*Oncorhynchus tshawytscha*) and Atlantic Salmon (*Salmo salar*), and native White Sucker (*Catostomus commersonii*)
- Five live spawners of each species were captured from northern Michigan rivers during peak spawning runs
- Each individual fish was placed in a separate aerated container of 40-L of stream water for 8 hours

- Filtered water samples were collected prior to and after fish addition
- Samples were analyzed for dissolved phosphorus (SRP), ammonium (NH_4^+), and carbon (DOC), and then standardized by wet mass of fish
- Theoretical excretion-based nutrient concentrations were calculated using excretion (µg /kg of fish/d), total fish biomass (kg), and Q (m^3/s)

Results & Discussion

- Mean hourly NH_4^+ concentrations and slopes of excretion were similar among species, whereas SRP excretion rates were 2-5x higher for non-native Atlantic Salmon and DOC secretion rates were 3-16x higher for non-native Chinook Salmon (Figures 1 and 2)

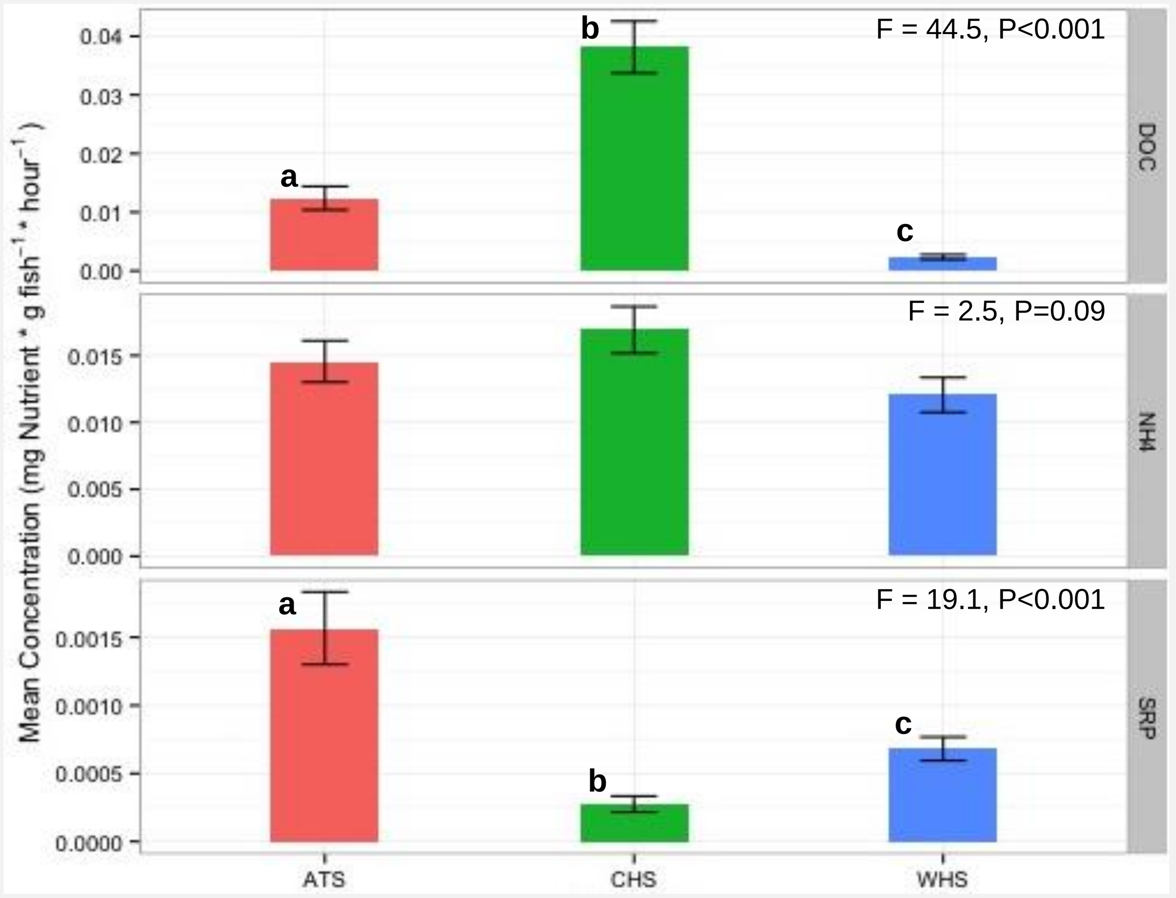

Figure 1. Mean (±SE) concentration of DOC, NH_4^+, and SRP secreted and excreted by Atlantic Salmon (ATS), Chinook salmon (CHS), and White Suckers (WHS).

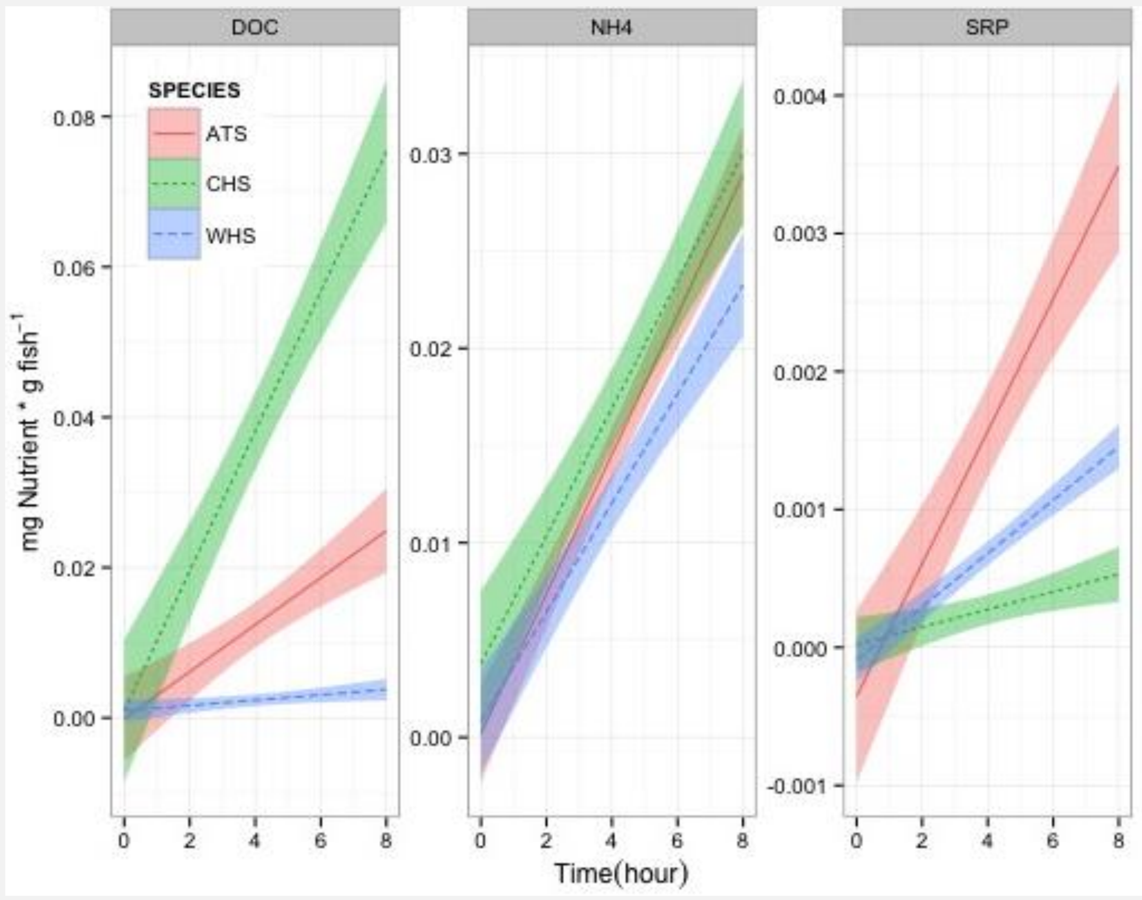

Figure 2. Excretion rates over 8-hour study period for Atlantic Salmon, Chinook salmon, and White Suckers. Lines represents mean and shading represents 95% CI.

- Subsidies varied by nutrient, species, run size, and stream size, with non-native species (CHS and ATS) contributing more dissolved nutrients than WHS under all scenarios, and small streams most strongly influenced by spawning migration subsidies (Table 1)

Table 1. Theoretical nutrient concentrations (µg/L) in Great Lakes tributaries due to daily excretion by spawning Atlantic Salmon, Chinook Salmon, and White Suckers under varying hypothetical scenarios of run size (spawner biomass) and stream size (discharge), and assuming no biological uptake.

	Scenario A High biomass, High Q[b]			Scenario B High biomass, Low Q[b]			Scenario C Low biomass, High Q[b]			Scenario D Low biomass, Low Q[b]		
Species	DOC	NH4	SRP	DOC	NH4	SRP	DOC	NH4	SRP	DOC	NH4	SRP
ATS	0.7	0.9	0.1	72.3	85.2	9.3	<0.1	<0.1	<0.1	1.5	1.7	0.2
CHS	7.3	3.2	0.1	730.3	323.9	5.8	0.2	0.1	<0.1	14.6	6.5	0.1
WHS	0.2	0.8	<0.1	15.3	80.7	4.7	<0.1	<0.1	<0.1	0.2	0.8	<0.1

[a] High biomass was based on 5,000 spawners for ATS & CHS and 10,000 for WHS; low biomass based on 100 spawners for all species
[b] High discharge was set at 50 m^3/s (4^{th}-5^{th}-order stream) and low discharge at 0.5 m^3/s (2^{nd}-3^{rd}-order stream) for all species

- We found evidence of differences in excretion rates among species and for different nutrients, with broader ecological implications, especially with respect to understanding the influence of cross ecosystem resource subsidies (cf. Lamberti et al. 2010)
- Excretion rates of other Great Lakes migratory species (e.g., *Moxostoma* spp., Steelhead) should be measured to understand how changes in migratory fish run size and composition may alter nutrient loading to tributaries, affecting stream productivity and food web dynamics

Literature Cited

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