

The Asian Clam *Corbicula fluminea*: Seasonal Filtration Rates of Representative Populations in Two Tributaries of the Delaware River

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Introduction

The Asian clam, *Corbicula fluminea* (Fig. 1), is a benthic filter-feeding bivalve that lives in freshwater. *C. fluminea* is indigenous to Southeast Russia and Asia and was introduced to the United States in the early 1930s. Asian clams were first reported in the Delaware River system in 1971 and have continued to proliferate across the country (Fig 2). To date, clams have been documented in more than 40 states and the District of Columbia.

As a filter-feeding bivalve, *C. fluminea* has the potential to provide valuable particle removal services where they are abundant. However, there are limited data on filtration rates of the Asian clam and the data that exist do not capture seasonal conditions well.

The Asian clam's life cycle promotes rapid growth and reproduction (Fig. 3) which contributes to its success as an invasive species. Clam population densities have shown considerable spatiotemporal variation across the country but often are reported above 1000 clams/m². Such dense populations of clams may have large ecological impacts within their respective streams. Currently, there are limited studies on clam demographics in the Delaware River basin.

This study aimed to measure seasonal filtration rates of *C. fluminea* within two tributaries of the Delaware River and track seasonal population demographics of *C. fluminea* to capture changes over varying environmental conditions (e.g. temperature, food quality and quantity). Data gathered shall provide a better understanding of the functional role *C. fluminea* plays in the Delaware River system.



Figure 1. The Asian clam, *Corbicula fluminea* burrowed in sand.



Figure 2. Dense bed of Asian clams in the Delaware River.



Figure 3. Juvenile clams found in population surveys.

Objectives

- Monitor seston quality and quantity by season in study streams.
- Measure seasonal clearance rates of Asian clams in study streams.
- Track and monitor seasonal Asian clam population demographics in study streams.
- Estimate potential particle removal services provided by Asian clams in study streams.

Terminology

Clearance rates refer to the volume of water cleared of particles by filter-feeders per unit time.

Filtration rates refer to the mass of particles removed from the water column by filter feeders per unit time.

Both measures scale with organism body mass and hence, these rates are best expressed per unit mass dry tissue weight (DTW) of the filter-feeder.

Study Streams

Study streams were chosen to be representative of common stream types in the lower Delaware River basin. Additional criteria included safety/logistics, clam population abundance and stream characteristics (e.g. morphology, turbidity). Notable differences between streams include substrate type and turbidity seen in Figures 4 and 5 as Cooper is a coastal plain stream and Red Clay is a piedmont stream.

Cooper River, NJ



Figure 4. Run section of Cooper River in Cherry Hill, NJ.

Red Clay Creek, DE



Figure 5. Run section of Red Clay Creek in Stanton, DE.

Methods

Clearance Rate Experiments

- 60 beakers (1 liter) set up (Fig. 6) with filtered stream water.
- Clams individually placed into beakers (n=24, per stream)
- Control beakers without clams (n=6, per stream)
- Well-mixed water samples (n=5) taken in each beaker at 30 minute intervals for 2 hours, fixed with Lugol's iodine.
- Stream water seston filtered onto pre-weighed glass fiber filters.
- Feces collected and clams sacrificed.

Experiment repeated for 3 seasons:
Spring (18°C); **Summer** (23°C); **Fall** (12°C)

- Dried and ashed seston filter weights obtained with digital balance. Water samples analyzed with a Coulter Counter Multisizer II to measure particle disappearance. Clearance rates calculated as per Coughlan (1969). [Coughlan, J. (1969). The estimation of filtering rate from the clearance of suspensions. *Mar. Bio.*, 2(4), 356-358]

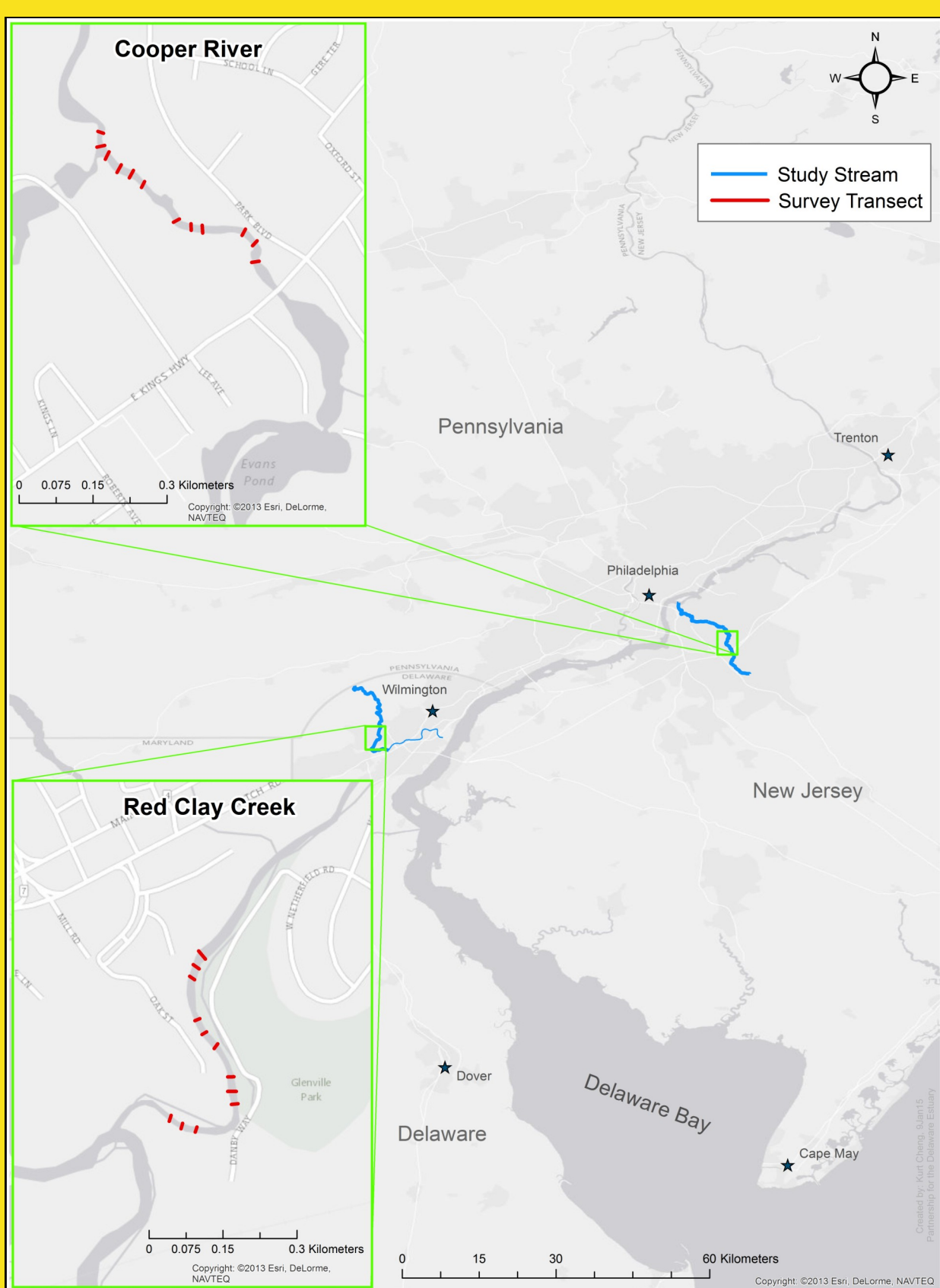


Figure 7. Study streams and population transects.



Figure 6. Beakers for clearance rate experiments; Asian clam shown in beaker.

Population Surveys

- Streams set up with 3 transects within 4 reaches (Fig. 7). Reaches were positioned 70m apart; transects were positioned 30m apart.
- Long scoop and bucket used to take triplicate 1-L grab samples at left, center and right transect positions (i.e. left to right bank)
- Adult clams collected and shell lengths measured (Fig. 8).
- Sediment sample kept for lab counting of juveniles (Fig. 9).



Figure 8. Processing population survey samples.

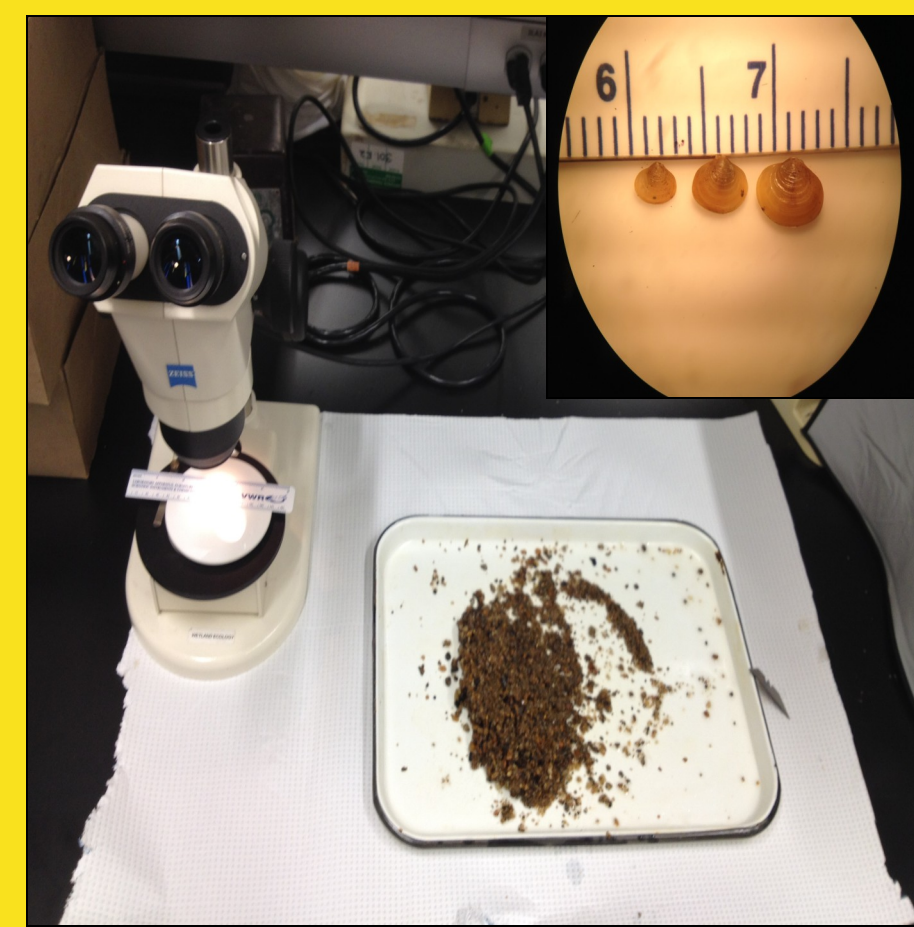


Figure 9. Sorting and measuring juvenile clams.

Population Level Bulk Filtration Estimates

- Compare dry weight/m² of clams to the mass of particles filtered per unit time.
- Repeat seasonally for each stream

Preliminary Results

Seston Analysis

- Concentration of particulate matter (Fig. 10) was significantly higher in Cooper River than Red Clay among all seasons (post hoc Tukey test, p<0.001)
- Concentration of particulate matter was significantly higher in spring than summer and fall in Cooper River (post hoc Tukey test, p<0.001) as well as Red Clay (post hoc Tukey test, p<0.001).

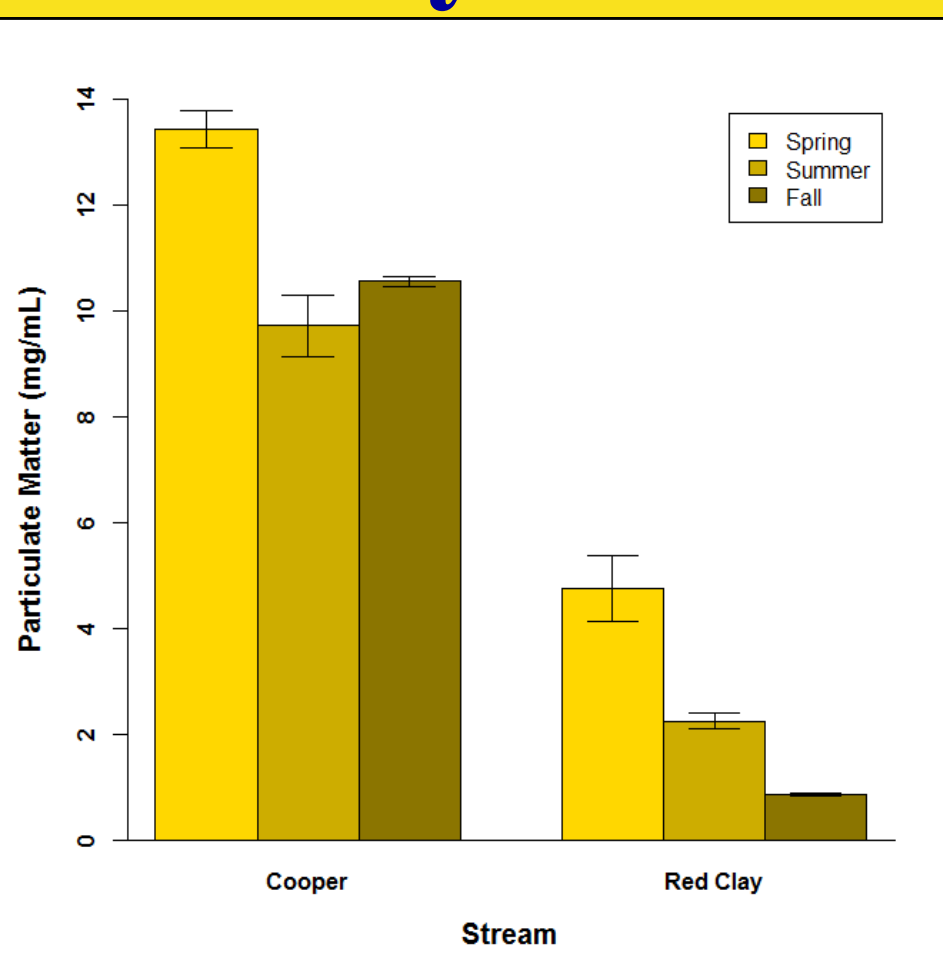


Figure 10. Particulate matter concentration between streams and across seasons. (standard error of means shown)

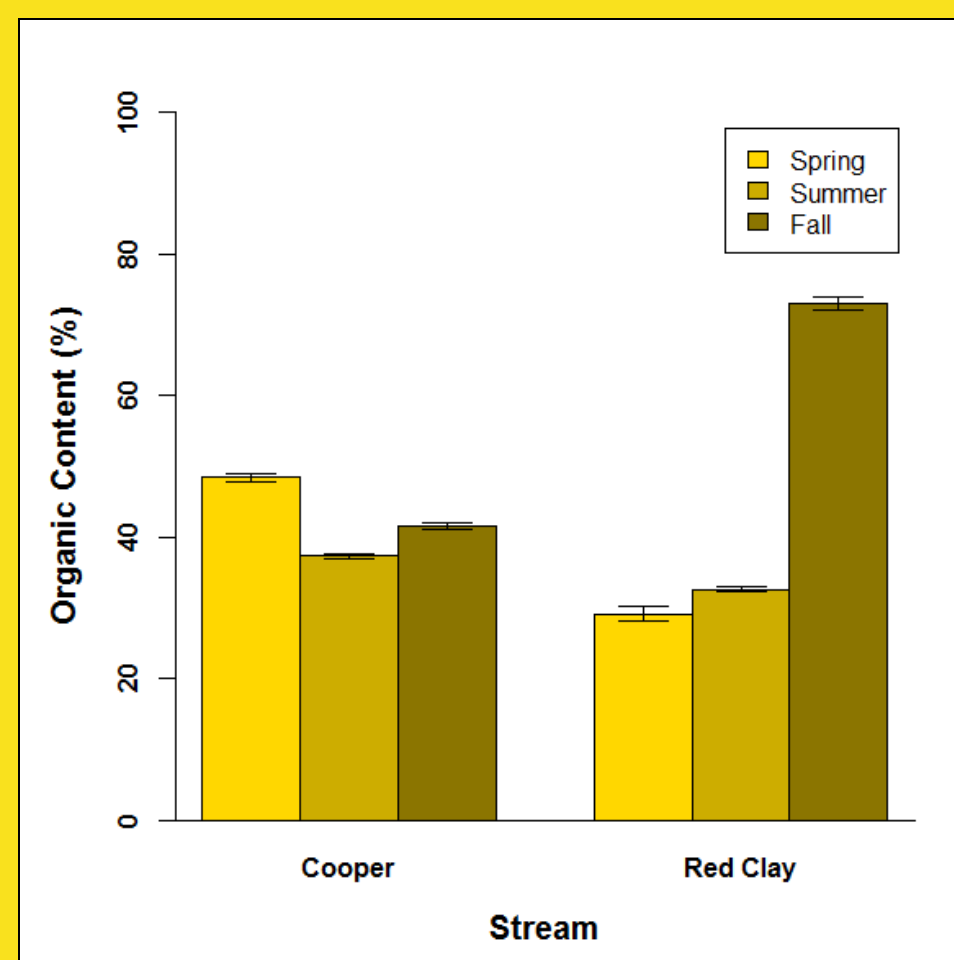


Figure 11. Percent particulate organic matter between stream and across seasons. (standard error of means shown)

- Percentage of organic content of particulate matter (Fig. 11) was significantly different in Cooper River among seasons and was highest in spring (post hoc Tukey test, p<0.05). (Data were arcsine square-root transformed for analysis.)
- Percent organic content of particulate matter in Red Clay was significantly higher in fall than in spring or summer (post hoc Tukey test, p<0.001).

Clam Population Analysis

- Average adult shell length (Fig. 12) was significantly higher for Cooper clams than for Red Clay clams among seasons (post hoc Tukey test, p<0.05).
- Adult clams (shell length >8mm) were found in abundance in all surveys (Fig. 13). Juvenile clams were found in all surveys and their abundances varied widely up to 440 individuals.

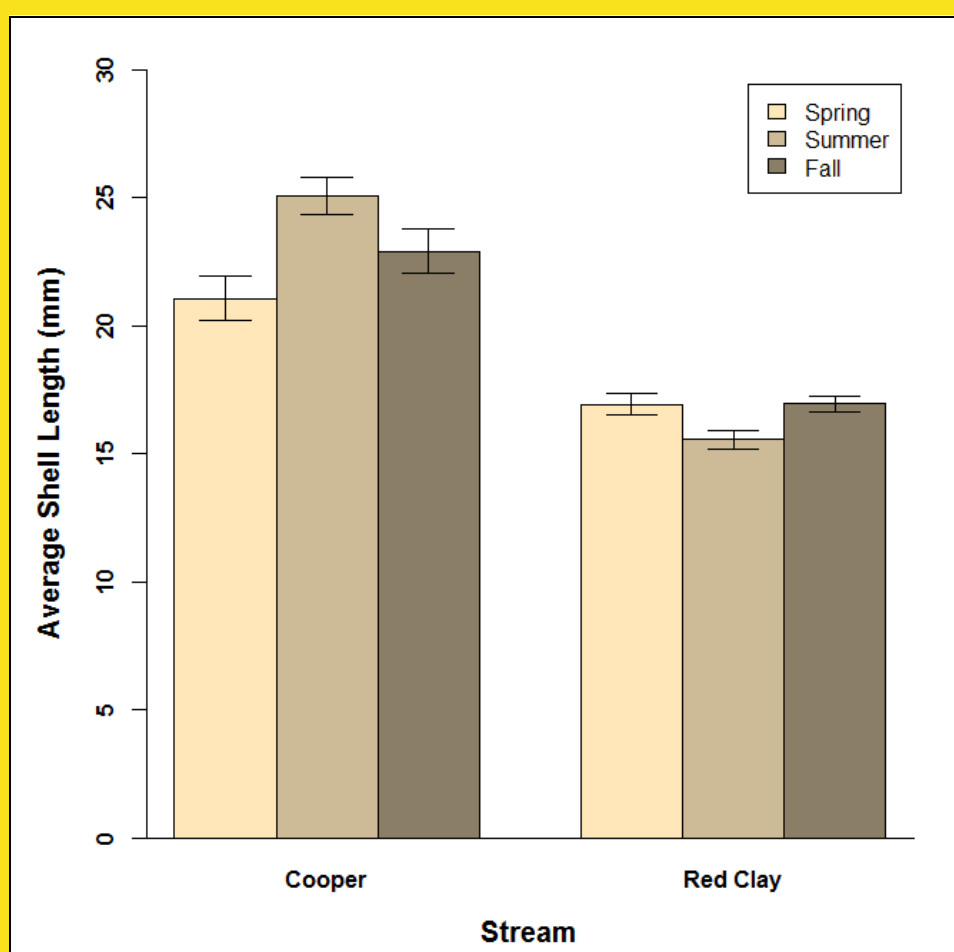


Figure 12. Adult clam shell length averages by stream and season. (standard error of means shown)

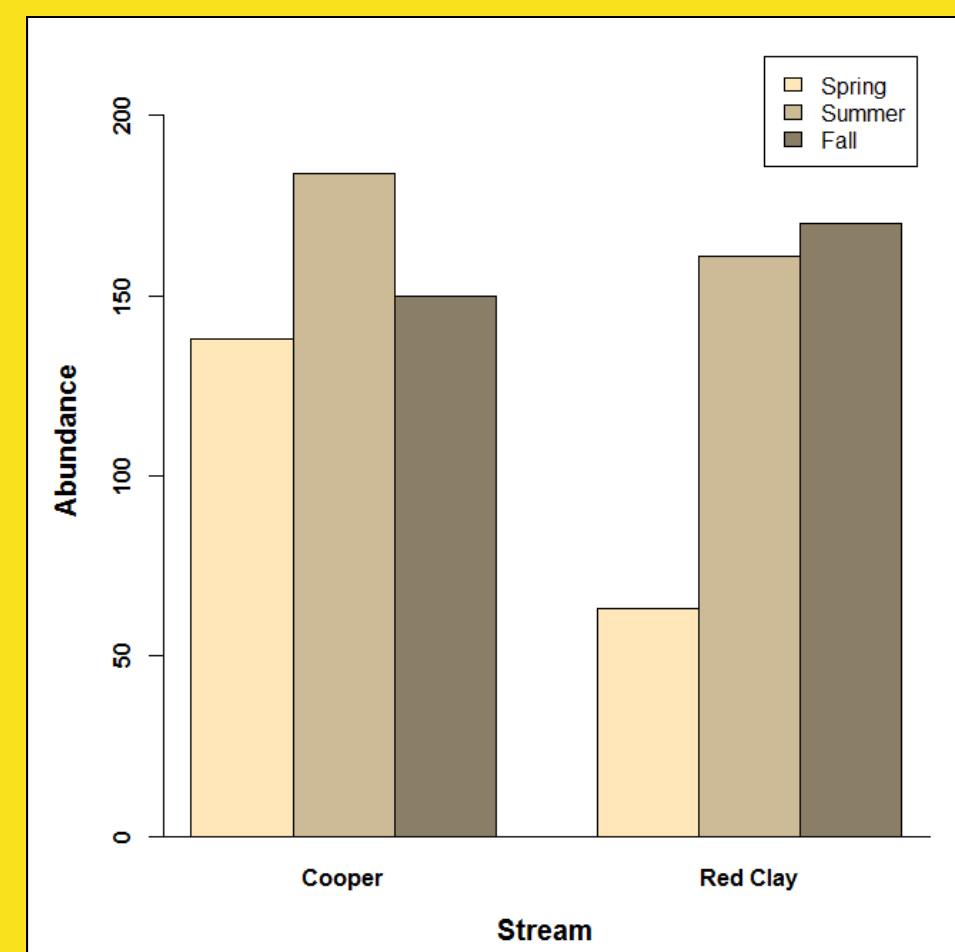


Figure 13. Adult clam abundance by stream and season.

Preliminary Results

Clearance Rates (L/hr/g DTW)

- Allometric clearance rates of Cooper River clams (Fig. 14) were not significantly different among seasons (1-way ANOVA p>0.05).
- Allometric clearance rates of Red Clay clams were significantly lower in fall than in spring or summer (post hoc Tukey test p<0.0001)

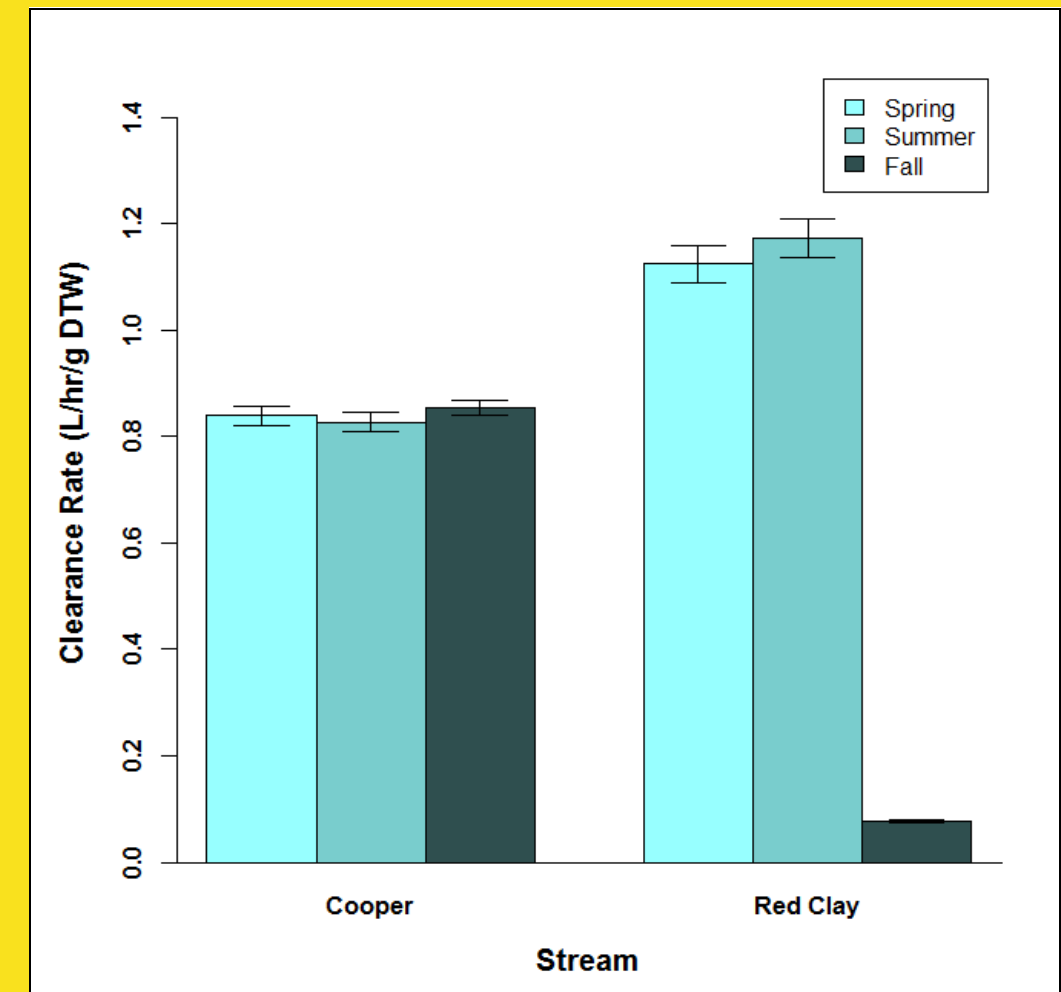


Figure 14. Asian clam clearance rate between streams and across seasons. (standard error of means shown)

Filtration Rates (mg/hr/g DTW)

- Allometric filtration rates (Fig. 15) were significantly higher for Cooper River clams than for Red Clay clams among all seasons (post hoc Tukey test, p<0.005).
- Allometric filtration rates were significantly different among seasons with a spring-fall decline for Cooper River clams (post hoc Tukey test, p<0.005) and for Red Clay clams (post hoc Tukey test, p<0.001).

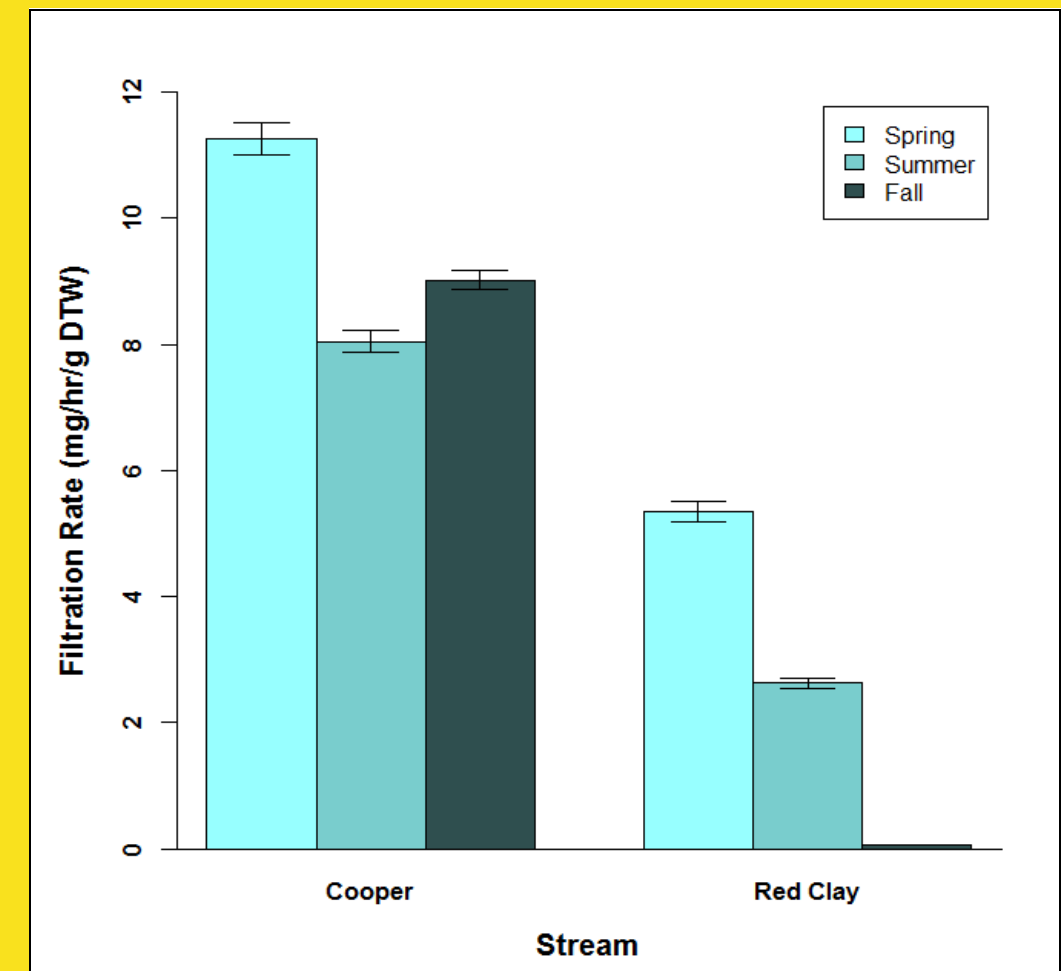


Figure 15. Asian clam filtration rate between streams and across seasons. (standard error of means shown)

Bulk Filtration Estimates

Table 1. Summary of filtration capacity, population biomass and annual bulk filtration estimates of the Asian clam.

	Cooper River			Red Clay Creek		
	Spring	Summer	Fall	Spring	Summer	Fall
Mean Filtration Rate (mg/hr/g DTW)	11.26	8.03	9.01	5.34	2.62	0.06
Mean Population Clam Size (g DTW/clam)	0.09	0.14	0.11	0.04	0.03	0.04
Mean Population Clam Density (# clams/m ²)	127.77	170.37	138.88	58.33	149.07	157.41
Mean Biomass Density (g DTW/m ²)	11.33	22.93	14.93	2.27	4.33	6.15
Estimated Seston Removal (mg seston/m ² /hr)	127.51	184.15	134.54	12.11	11.33	0.368
Estimated Annual Filtration (kg seston/m ² /yr)	0.96			0.05		
Annual Filtration within 1 km reach (metric ton seston/yr)	8.5			0.72		

Discussion

- Cooper River clams demonstrated consistent clearance rates over three seasons. Seston concentration varied little seasonally and percentage of organic content remained constant over the year. Taken together, filtration rates of clams in Cooper River were consistently high likely due to continuous availability of food.
- Red Clay clams' clearance rates, and therefore filtration rates, dropped precipitously from summer to fall, likely due to a decrease in available seston. In Red Clay, clams likely adjusted their foraging strategy and became quiescent in fall in response to low seston concentration.
- Cooper River clams were significantly larger than Red Clay clams which reflects the availability of food to Cooper River clams and their respectively higher filtration rates.
- Due to higher concentration of seston and larger clams, Cooper River clams filter more per year than Red Clay clams.

Next Steps

- More analysis of ecosystem services will be done by relating population demographics to allometric-scaled seston filtration.
- Analysis of feces samples to estimate net removal vs. recycling of organic fraction.
- Frame ecosystem services relative to flow rates of study streams.

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