NATURAL CAPITAL APPLICATIONS AT THE PARTNERSHIP FOR THE DELAWARE ESTUARY

Priscilla Cole and Danielle K. Kreeger, Partnership for the Delaware Estuary, 110 S. Poplar St., Ste.202, Wilmington, DE 19801

Abstract

The Natural Capital Team at the Partnership for the Delaware Estuary has developed tools over the past two years to assist in various projects in the Delaware Estuary, including freshwater mussel restoration, climate change planning, and regional restoration planning. One case study focused on the ecosystem benefits provided by the freshwater mussel, *Elipito complanata*. Specific ecosystem services furnished by *E. complanata* were identified and estimated based on literature values for key physiological rate functions and ecosystem process functions. These included production, clearance rate, total suspended solids removal, chlorophyll-a removal, sediment organic enrichment, sediment stabilization, macroinvertebrate habitat improvement, nutrient processing flux, and the sequestration of nitrogen and phosphorus. These metrics were related to the estimated population biomass of Elliptio in the Delaware Estuary and conditions such as loadings of pollutants.

Mass balance estimates suggest that even the diminished current population of mussels represents ecologically important natural capital because of the ecosystem services that are furnished, including stormwater pollutant reduction and nutrient control. Estimating the services provided by Elliptio and other bivalve mollusks has implications for water quality standards and TMDL attainment strategies. Restoration of freshwater mussels such as Elliptio provides opportunities to enhance these services, improve water quality and habitat conditions, and build system resilience as an offset for the effects of climate change and continued watershed development.

One case study for our natural capital looked at the services provided by an aquatic mussel species, which is considered a heavy hitter in the Delaware Estuary system both in terms of population abundance and ecosystem benefits. *Elliptio complanata* (referred to here as ELCO) is a species of freshwater mussel (Family: Unionidae) that was historically found throughout the Estuary, and is still one of the most common species of mussels in the basin. Unfortunately, the distribution of all freshwater mussels has become greatly reduced, and even ELCO is now only found in a small fraction of streams and rivers. But where it is still found, it can exist in impressive numbers despite centuries of degradation to its habitat, water quality, and fish hosts.

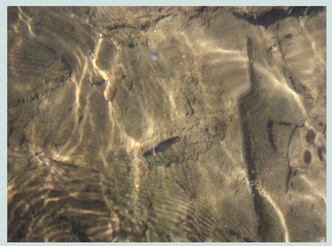
Because it is readily available for study, ELCO serves as a "white rat" of the freshwater mussel assemblage. Unlike most of the 300 native mussel species in North America, there are data on the physiological rate functions and abundance of ELCO, information which is needed to tally ecosystem services. ELCO is also an important restoration target at the Partnership, in a program called the Fresh Water Mussel Recovery Program (FMRP).

Elliptio complanata: Ecosystem Service Giant

We estimate that there are at least 2 million adult ELCO in the Delaware Estuary study area. At this population abundance, the combined assemblage can be estimated to filter 4.6 billion liters of water an hour during the spring to fall period, or about 39.9 trillion liters a year. In comparison to reported loadings of pollutants, we can construct a simple mass balance estimate of the water quality benefits from this biofiltration by mussels. We have estimated how many kilograms a year ELCO are filtering for major particulate pollutants such as total suspended solids, particulate nitrogen and phosphorus, and chlorophyll-a.

Types of Services

Bivalves have long been regarded worldwide as some of the best bio-indicators of environmental conditions, particularly of long-term status and ecosystem health. Where abundant, they are referred to as "ecosystem engineers" because they modify habitat and can dominate functional processes by large scale filter-feeding at the base of the food chain. Bivalves filter suspended solids, phytoplankton, detritus, and perhaps even pathogens resulting in water quality improvement. Mass filtration leads to an increase in light penetration though the water column, improving growing conditions for bottom plants and algae. Their bio-deposits enrich sediments which benefit other fauna and flora. They also provide structural complexity and stabilize stream bottoms, providing habitat for other organisms.



Elliptio complanata live in the bottom of streams, rivers, and ponds such as the picture above. Just the lip of the mussel can usually be seen sticking out of the sediment, while most of the mollusk remains buried. This small opening is all the mussel needs to filter water.

Freshwater Mussel (*Elliptio*) Ecosystem Services

Service	Rates	Service @ 2009 Populations
Production	1-20g (dry tiss. mass)/m^2 /yr[17, 18]	11.8 Million–236.9 Million kg/yr
Clearance Rate	3.4 L /g (dry tiss. mass)/hr[8]	39.9 Trillion L/Yr
TSS Removal	Amount filtered/Estimated Load[8, 16]	758 Million kg TSS/Yr
Chlorophyll-a Removal	Amount filtered /Estimated Load[16]	251 Million kg/Yr @90% capture efficiency
Sediment Org.Content	Increased by 50% with live mussels [8]	
Particulate Phosphorus Processing & Sequestr.	Assimilated in Tissues = 17%[12]	19.0 Thousand kg/Yr
	Bound up in Sed. Dep. = 64% [12]	71.5 Thousand kg/Yr
	Transformed o Inorganic-P = 15% [12]	16.8 Thousand kg/Yr
Particulate Nitrogen Processing & Sequestr.	Nitrogen Processed	8.0 Million kg/Yr
	Inorganic Ammonia Excretion Rate = 61.88µg/mussel/hr [18]	1.08 Million kg/Yr
Sediment Stabilization	Sheer Strength: Up 24% Compression: Up 31% [21]	
Invertebrate Habitat	25% higher (yearly) populations with live mussel [14]	

Calculation Notes

It is important to note that such calculations are fraught with potential errors and assumptions. One assumption is that 'pollutants' are evenly distributed in the water column, meaning that ELCO have equal access to the ambient loads for filtration. This is probably not the case throughout the system. Most streams also no longer harbor mussels. And where abundant, mussels can re-filter the same water if the residence time is sufficiently long. Nevertheless, a first order mass balance estimate of natural capital benefits can be made, understanding that the outcome represents the "potential" and not necessarily "actual" benefits.

Prime habitat for *Elliptio complanata* looks like the picture above, in freshwater forested headwaters. Streams with healthy riparian forests provide suitable water quality and habitat conditions, making good locations for ELCO reintroduction.

ELCO Restoration = Ecosystem Services Restoration

Fresh Water Mussel Recovery Program (FMRP)

The goal of the FMRP is to reintroduce Elliptio mussels into streams which once historically held populations, and are still suitable habitat. The first step of the FMRP was to determine which streams could still support Elliptio through a series of Brandywine/Christian surveys in 2007 and 2008. Elliptio were put out in little cages in these streams for one year, and then collected and analyzed for health. The second step was to figure out how to raise baby Elliptio in a lab at Cheyney University so that they could be seeded into the suitable rivers. Propagating Elliptio had never been attempted before, so Cheyney had to do many experiments to get the right conditions and fish hosts. American Eel turned out to be one of the best fish hosts for raising Elliptio in a lab setting. The eventual goal of the FMRP is to produce and plant 10,000 juvenile Elliptio in several streams in the Christina watershed. Once planted, the seed will be monitored to gauge growth and project success. Each batch of 10,000 seed is projected to filter 0.8 million liters of water in their first year in-stream.

Threats: Climate Change

ELCO are considered to be vulnerable to climate change from environmental factors such as temperature increases which may interfere with the timing of spawning or host fish migration. Since ELCO populations are far below their carrying capacity in most streams today, this analysis suggests that water and habitat quality can be improved over today's conditions by simply restoring mussel populations back toward their carrying capacity.