Use of Freshwater Mussels to Improve Water Quality within the Reflecting Pool at Constitution Gardens

Report to the National Park Service
Harriette L. Phelps, Biology Department
University of the District of Columbia
4200 Connecticut Ave. NW
Washington, DC 20008
2005

Use of Freshwater Mussels to Improve Water Quality within the Reflecting Pool at Constitution Gardens

Report to the National Park Service
Harriette L Phelps, Biology Department
University of the District of Columbia
4200 Connecticut Ave. NW
Washington, DC 20008
2005

<u>Introduction and Summary</u>

This is the final report on a one-year National Park Service grant to study the possible use of native freshwater mussels to improve water quality at the Constitution Gardens Reflecting Pool (next to the Lincoln Memorial Reflecting Pool). In the fall the Constitution Gardens Reflecting Pool becomes turbid with dense microalgal blooms due to warm temperatures, extended daylight hours, and runoff from lawns, leaves, and goose droppings. In the nearby Potomac River the large Asiatic clam (*Corbicula fluminea*) population has been associated with reduction of Potomac microalgae blooms. The objectives of this project were to make observations on the water quality of the Constitution Gardens Reflecting Pool to determine if native mussels can survive and grow in the Pool, determine filtration efficiency of native mussels, and estimate the biomass of mussels needed to reduce summer algal blooms in the Pool.

In a number of shallow-water ecosystems an increase in benthic mollusc populations has resulted in dramatic water clarity improvement. This effect has been found in northern San Francisco Bay with the introduced exotic Asian clam *Potamocorbula ameurensis* (Cloern and Alpine 1991), in the Great Lakes and the Hudson River with the introduced exotic Zebra mussel, *Dreissena polymorpha* (Strayer e.a. 1999, Budd e.a. 2001), and in the Potomac River with the introduced exotic Asiatic clam *Corbicula fluminea* (Cohen e.a. 1984; Phelps 1994).

Reduction of microalgal blooms and maintenance of improved water quality has been suggested as a function of bivalve suspension feeding (Herman and Scholten 1990). The positive relationship between bivalve filtration rate and water quality (Newell 2004) includes the Potomac River (Lauritsen 1986), the Great Lakes (Fanslow ea 1995) and the Chesapeake Bay by the native oyster *Crassostrea virginica* (Ulanowitz and Tuttle 1992). Lake water quality management has been suggested using the zebra mussel in the Netherlands (Reeders e.a. 1989). Although the local Asiatic clam population has been linked to water quality improvement in the nearby Potomac (Phelps 1994) it is an exotic species and could not be introduced at Constitution Gardens.

Citation: Phelps, H.L. 2005. Use of Freshwater Mussels to Improve Water Quality within the Reflecting Pool at Constitution Gardens. National Park Service, Washington, DC 8p

The most common native mussel in this region is the Eastern Elliptio, *Elliptio complanata* (Lightfoot, 1786*)* (http://www.biosci.ohio-state.edu/), and the Potomac River is the type location for this species. This large common unionid mollusc was selected as the best native species for use in Constitution Gardens. Principal aspects of the present project were to evaluate growth and survival of *E. complanata* placed in the Constitution Gardens Reflecting Pool, and to estimate clearance rate to evaluate mussel use for water quality improvement. Filtration rate in molluscs is different from clearance rate which is the ability to remove particles from water (Mohlenber and Riisgard 1979), and the clearance rate was studied for the purposes of this project.

<u>Materials and Methods</u>

In November 2004 continuous recording temperature monitors (TidbiT, Onset Corp.) were placed in the Constitution Gardens Reflecting Pool at two sites on opposite sides of the island bridge, site CG1 near the large island, (N38^{0}53’472”, W077^{0}02’554”) and site CG2 near a pool—planted tree, (N38^{0}53’472”, W077^{0}02.540) (Fig. 1). On June 15, 2005 the USGS Science Center at Leetown VA collected adult *E. complanata,* from the local Potomac River for this study. The mussels were scrubbed, numbered by writing on a scoured shell area, and individually weighed and measured (shell length). The mussels were kept cool overnight. On 6/16/05 the mussels were placed in two lots of 12 in shellfish bags at CG1 and CG2 sites in the Constitution Gardens Reflecting Pool, and a third set of 12 mussels with a TidbiT monitor placed at the control site GL, Greenbelt Lake, MD, (N39^{0}00’240”, W076^{0}53’510”).

Figure 1. Constitution Gardens Reflecting Pool. Washington, DC

On 8/23 the mussels were retrieved, re-weighed, re-measured and replaced, and on 12/8/05 were retrieved, re-weighed, re-measured and removed. The original numbering was difficult to read so the mussels were re-numbered with a shell scratch system that proved effective.

The average clearance rate of *E. complanata* mussels was estimated in the laboratory using native microalgae from a eutrophic pond. On 6/27/05 and 8/16/05 field trips were made to Hunting Creek Fisheries, Thurmont MD, to collect water from their goldfish–rearing ponds, which have very dense phytoplankton communities (Phelps 2002). On 8/3/05 additional *E. complanata* were collected from the nearby Potomac River for clearance rate experiments, on 8/7 – 10. On 8/16/05, *C. fluminea* were collected from the clean Potomac River above Great Falls at Warmwater State Park, MD for a comparison clearance rate experiment conducted on 8/18. Individual molluscs were placed in 600 ml (*E. complanata*) or 300 ml (*C. fluminea*) of pond algal suspension. The control had no molluscs. Turbidity was recorded bi–hourly for four to six hours using a MicroTPI portable turbidimeter (HLF Scientific, Inc.). The most consistant determination of clearance rate was achieved by averaging five readings taken at 0, 2 and 4 hours with removal of flocculated algae after each turbidity measurement.

The clearance rate was calculated from the decrease in algal concentration according to Coughlan's (1969) formula: $m = (M/nt) \ln (C_O/C_t)$, where m = clearance rate (ml/mussel/hr); M = volume of the test solution; n = number of animals per container; t = duration of the experiment (h); C_O = algal concentration at the beginning of the experiment, and C_t = algal concentration at time *t.* Algal concentration was measured in NTU (National Turbidity Units).

Calculations of the amount of mussels needed to clear the Constitution Gardens Reflecting Pool were made for a pool size of 6.8 acres having an average depth of 30 –36 inches (pers. comm., National Capitol Area Park Service).

Results

There was no mussel mortality at any site. The TidbiT temperature monitor indicated summer water temperatures ranged up to 32 deg C, and fell as low as 5 deg. C. After 10/16 the water temperatures dropped below 10 deg C, when the mussels presumably ceased filtering. The *E. complanata* collected from the Potomac in June and August were observed to be shedding white packets of embryos. However, the average mussel weight at the three locations did not change significantly from June through December with the exception of a slight initial weight gain at the CG2 location in Constitution Gardens (Table 1).

The E. complanata mussels caused a significant linear drop in algal suspension turbidity (NTU) over a period of four hours as compared to control (Figure 2). The *C. fluminea* clams also caused a significant linear drop in algal suspension turbidity (NTU) over a period of six hours as compared to control (Figure 3).

Table 1. Total wet weight including shell of individual *Elliptio complanata* at Constitution Gardens Reflecting Pool locations (CG1, CG2) and at Greenbelt Lake (GL) from 6/16/05 to 12/8/05.

	CG1(WWT,GM)			CG2(WWT,GM)			GL(WWT,GM)		
#	6/16	8/23	12/8	6/16	8/23	12/8	6/16	8/23	12/8
0	23.3	24.1	24.8	27.3	49.7	49	34.9	36.5	36.1
1	26.4	26	25.6	38.6	64.6	75.2	37.5	37.4	37.1
2	30.8	29.9	29.9	43.2	60.4	68.8	39.7	40.8	40.1
3	30.8	31.3	30.8	52.5	84.5	82.8	53.2	55.3	55
4	32.7	31.1	30.5				57.8	57.9	58
5	31.6	31.8	33	51	52.3	51.5	57.5	57.8	56.9
6	41.6	42.6	42.8	46	72.2	71.7	44.9	47.2	4.5
10	30.4	30.3	32.8	58.5	54.3	51.7	60.1	60.7	60.5
11	51.9	50.2	50.8	57.4	52.9	52.4	58.6	59.3	49.7
12	54	53.7	54.5	50.8	62	65.2	48.6	50	58.8
13	64.7	63.4	63.4	47.8	45.6	45.9	47.3	47.1	46.7
14	80.8	82.6	82.8	67.3	53.3	53.8	75.9	77.1	76.4
15				57.1	55.1	54			
SUM	499	497	501.7	540.4	706.9	722	616	627.1	579.8
MEAN	41.6	41.2	41.8	49.8	58.9	60.1	51.3	52.3	48.3
sd	17.67	17.85	17.81	10.43	10.81	12	11.59	11.55	17.9
se	5.1	5.15	5.14	3.01	3.12	3.46	3.35	3.33	5.17

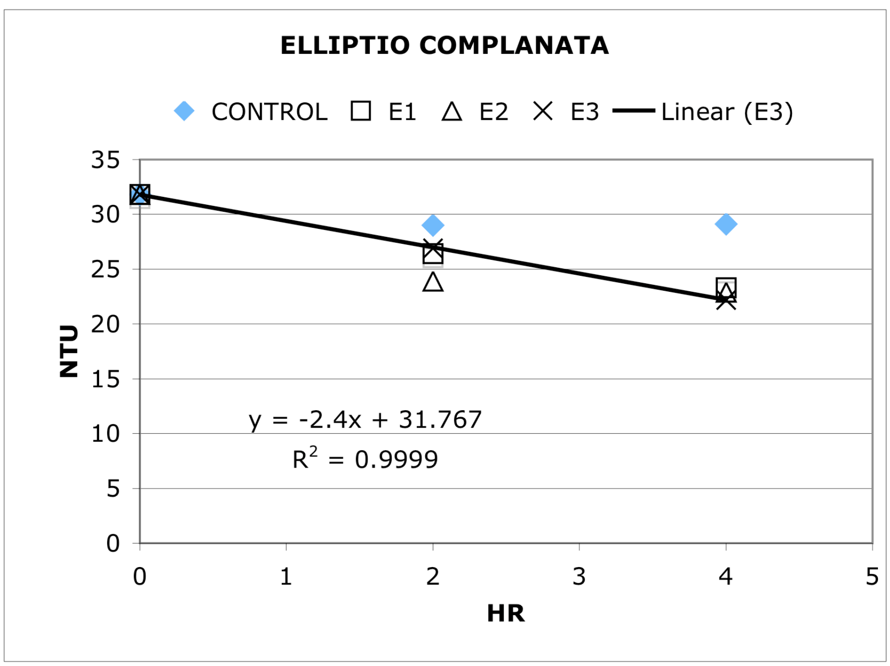

Figure 2. Clearance by individual *Elliptio complanata* mussels in 600 ml algal suspension.

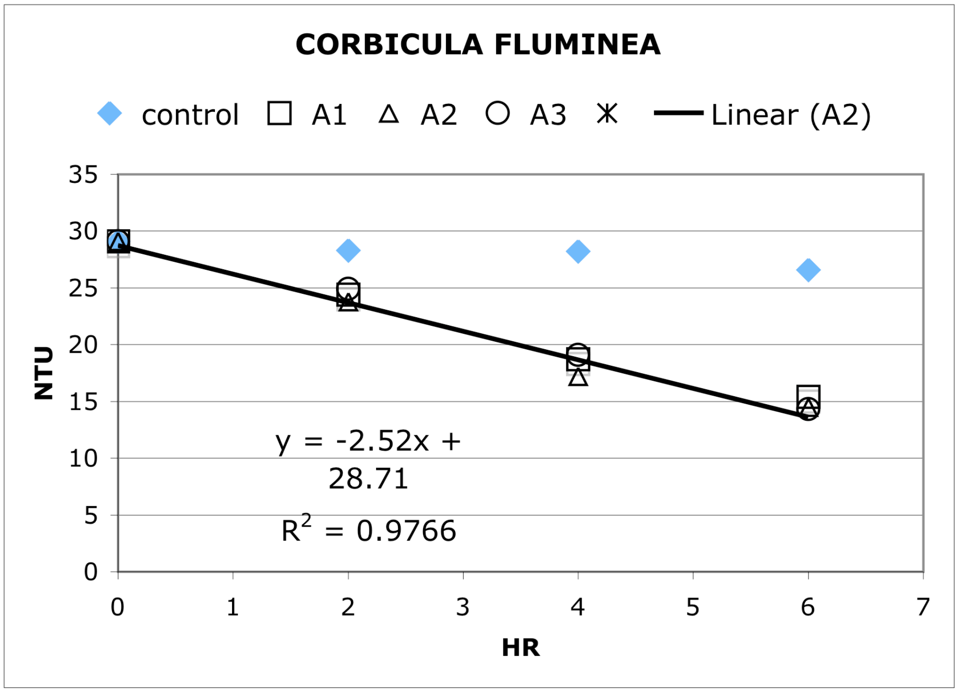

Figure 3. Clearance by individual *Corbicula fluminea* clams in 300 ml algal suspension .

There was considerable difference in size and clearance rate among the native unionid mussel (*E. complanata*) and the Asiatic clam (*C. fluminea),* both from the nearby Potomac River (Table 2). There was no significant relationship found among clearance rate and total wet weight including shell.

Table 2. Size and clearance rate among *Elliptio complanata* and *Corbicula fluminea* (standard deviation in parenthesis).

	Elliptio complanata	*Corbicula fluminea*
NUMBER OF STUDIES	11	3
AVG. LENGTH (MM)	78(29.0)	33
AVG. TOTAL WET WEIGHT (GM)	59(21.1)	10.4(0.2)
AVG. ML/HR/MOLLUSC	40.5(18.4)	101(21.1)
COEFFICIENT OF VARIATION	45%	21%
AVG. ML/HR/GM	0.52	9.71

Discussion and Conclusions

Although *E. complanata* could not be placed in sediment at the Constitution Gardens Reflecting Pool as they would be in the Potomac River, they all survived the Pool conditions including typical temperature extremes from 32 to 5 deg. C. There was little or no increase in mussel weight at any site, including the Greenbelt Lake control, although the late summer water was highly eutrophic. These full size adult mussels which can live many years indicated that conditions at the Constitution Gardens Reflecting Pool were adequate for mussel survival if not growth.

Although there has been much interest and many studies on filtration and clearance rates of marine shellfish and invasive freshwater mollusc species, there are few published works on clearance rates in native mussels. Studies of filtration or clearance rate in mollusc species have used a variety of methods with widely differing results (Riisgard 2001). For example, determination of filtration rate in *C. fluminea* has ranged from 20 to 1370 ml/hr/clam (Lauritsen 1986, Phelps 1997). This variability in filtration/clearance rate has been interpreted as due to many factors including food density, experimental conditions, mollusc size and condition, pollution (Widdows 2001), inability to reproduce field conditions in the laboratory (Reeders et al 1989), etc.

The present clearance rate study found *E. complanata* averaged 40.5 ml/hr/mussel and *C. fluminea* averaged 101 ml/hr/clam (2.5X higher). These rates are not greatly different from those found in the study of Leff et al. (1990) comparing the two species with a *E. complanata* clearance rate of 10.9 ml/hr/mussel and *C. fluminea* at 43.2 ml/hr/clam. On a wet weight basis the Asiatic clam clearance rate here averaged 19X higher than the native mussel.

It can be calculated based on the clearance rates found in this study that enough *E. complanata* mussels to clear the entire 6.5 acre Constitution Gardens Reflecting Pool in one month clearing constantly at 40.5ml/mussel/hr would be: 6.8 acre-feet x 1,233,482 liters/acre-foot x 2.75 ft depth = 23.1×10^6 liters divided by 744 hours/month x 40.5 ml/hr/mussel = 766,678 mussels. This would be 99,515 lb of mussels, average weight 59 gm.
Similar calculations for *C. fluminea* give 307,409 clams or 7,033 lb of clams.

Although the proposal to use native mussels as a clearing agent for the Constitution Gardens Reflecting Pool is admirable and ecologically friendly, it would be a formidable amount of molluscs to collect and distribute in the Reflecting Pool as well as probably affect the sources in local rivers. The suggestion was good but the implementation is not advised.

Acknowlegements
Grateful acknowlegement is made to the USGS Science Center at Leetown VA which collected and supplied the native mussel, *Elliptio complanata.*
This project could not have been carried out without the excellent field and laboratory assistance of Earl Greenidge, a former UDC student (pictured).

Literature Cited

Budd, J.W.,T.D. Drummer, T.F. Nalepa and G.L. Fahnenstiel. 2001. Remote sensing of biotic effects: Zebra mussels (*Dreissena polymorpha*) influence on water clarity in Saginaw Bay, Lake Huron, Michigan. Limn. and Ocean. 46(2):213-223

Cloern, J. and A. Alpine. 1991. *Potamocorbula amurensis*, a recently introduced Asian clam, has had dramatic effects on the phytoplankton biomass and production in northern San Francisco Bay. J. Shell. Res. 10(1):258-259.
Cohen, R.R.H., P.V. Dresler, E.J.P. Phillips and R.L. Cory. 1984. The effect of the Asiatic clam, *Corbicula fluminea*, on the phytoplankton of the Potomac River, Maryland. Limn. and Ocean. 29:170-180.
Coughlan, J. 1969. The estimation of filtering rate from the clearance of suspensions. Mar. Bio. 2:356-8.
Fanslow, D., T.F. Nalepa and G.A. Lang. 1995. Filtration rate of the zebra mussel (*Dreissena polymorpha*) on natural seston from Saginaw Bay, Lake Huron. J. Gt. Lakes Res. 21:517-528.
Herman, P.M.J., and H. Scholten. 1990. Can suspension feeders stabilise estuarine ecosystems? p. 104-116 in M. Barnes and RN Gibson (eds), Trophic Relationships in the Marine Environment. Aberdeen University Press, Aberdeen, UK.
http://www.biosci.ohio-state.edu/~molluscs/Elliptio/elliptio_complanata.htm
Lauritsen, D.D. 1986. Filter-feeding in *Corbicula fluminea* and its effect on seston removal. J. N. Am. Benth. Soc. 5:165-172.
Leff, L.C., J.L. Burch and J.V. McArthur. 1990. Spatial distribution, seston removal and potential competitive interactions of the bivalves *Corbicula fluminea* and *Elliptio complanata*, in a coastal plain. Freshwater Biol. 24:409-416.
Mohlenber, F. and H.U. Riisgard. 1979. Filtration rate, using a new indirect technique , in thirteen species of suspension-feeding bivalves. Mar. Biol. 54:143-147.
Newell, R., 2004. Ecosystem influences of natural and cultivated populations of suspension-feeding bivalve molluscs: A review. J. Shell. Res. 23:51-61.
Phelps, H.L. 1994. The Asiatic clam (*Corbicula fluminea*) invasion and system-level ecological change in the Potomac River estuary near Washington, DC. Estuaries 17(3):614-621.
Phelps, H.L. 1997. Life History Data for the Asiatic Clam (*Corbicula fluminea*). Report to the Delaware River Corbicula Bivalve Project for the Delaware River Basin Commission (DRBC-F98D-1/2). 11p.
Phelps, H.L. 2002. Remote Sensing Spectral Identification of Freshwater Plankton Communities. Report to NASA. 11p.
Reeders, H.H., A. Bij de Vaate and F.J. Slim. 1989. The filtration rate of *Dreissena polymorpha* (Bivalvia) in three Dutch lakes with reference to biological water quality management. Freshwater Biol. 22:133-141.
Riisgard, H.U. 2001. On measurement of filtration rates in bivalves-the stony road to reliable data: review and interpretation. Mar. Ecol. Prog. Ser. 211:275-291.
Strayer, D.L., N.F. Caraco and J.J. Cole. 1999. Transformation of freshwater ecosystems by bivalves, a case study of zebra mussels in the Hudson River. BioScience 49:19-27.
Ulanowicz, R.E. and J.H. Tuttle. 1992. The trophic consequences of oyster stock rehabilitation in Chesapeake Bay. Estuaries 15:298-306.
Widdows J. 2001. Bivalve clearance rates: Inaccurate measurements or inaccurate review and misrepresentation? Mar. Ecol. Prog. Ser. 221:303-305.