Report for 2002DC5B: Bimonitoring Anacostia Watershed Pollutants

There are no reported publications resulting from this project.

Report Follows:

Corbicula Biomonitoring in the Anacostia Watershed

Final Report to the DC Water Resources Research Center
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ABSTRACT

The 10 km freshwater Anacostia River estuary of Washington, DC, is one of Chesapeake Bay's three Regions of Concern and one of America's ten worst 'rivers'. Concerns are a fishing advisory from chlordane and PCBs, and a depauperate benthos. Asiatic clams (Corbicula fluminea) from the nearby healthy Potomac River estuary were translocated to one Anacostia estuary site and 13 tributary sites for eight weeks, with tissues analyzed for 21 pesticides, 28 PCB congenors, 18 PAHs and 6 metalss. One site had clams with total metal bioacumulation significently increased over the Potomac reference level. At ten sites the clam tPAH bioaccumulation was above Potomac reference levels. Clams at two tributary sites had chlordane accumulation above the FDA fish consumption action level, and one site had tPCB accumulation above the FDA action level. Translocated clams showed significently increased contaminant concentrations within two weeks. Repeating clam bioaccumulation at four main tributary sites in 2001 and 2002 found 62% (10 of 16) contaminant levels statistically equivalent. It appears Anacostia estuary fishery-bioavailable contaminants of concern are coming from specific tributary sites, mostly located in Maryland. Corbicula translocation is a rapid freshwater 'Clam Watch' that can identify watershed reaches with major sources of bioavailable contaminants to the Anacostia estuary. These sources need to be considered for any Anacostia River remediation plan to be effective.

INTRODUCTION

The 10 km Anacostia River estuary continues to be a seriously impacted body of water that is a major focus of the District of Columbia. There is considerable evidence of toxic input from the fishing advisory (chlordane and PCBs) (Velinsky and Cummins 1994), fish tumors (PAHs) (Pinkney et al. 2000) and the depauperate benthos (Phelps 1985). Part I and II in 2001 was to begin to find the sources of bioavailable contaminants in the Anacostia watershed (Phelps 2002). Corbicula fluminea clams were translocated from the healthy Potomac estuary to three Anacostia estuary sites and four major tributaries just above head of tide. After eight weeks deployment the clam tissues were analyzed for EPA priority pollutants including 21 pesticides, 28 polychlorinated biphenyl (PCB) congenors, 18 polycyclic aromatic hydrocarbons (PAH)s and five metals (Cd, Cu, Cd, Fe, Zn). Clams at two tributaries (Northwest Branch, MD and Hickey Run, DC) had no contaminant class totals significently exceeding reference. Northeast Branch clam tPAHs exceeded reference clam contaminant levels by 300% and tPesticides by 150%. Lower Beaverdam Creek clam tPCBs exceeded reference by 400%.

Part III in 2002 -2003 developed several objectives. Objective A was to examine clam contaminant accumulation at two major remaining potential sources to the Anacostia, and the large Washington, DC O Street Sewage Pump Station Outfall (O Street outfall) and the Watts Branch tributary (DC/MD). Objective B was to localize contaminant sources in Northeast Branch (MD), Lower Beaverdam Creek (MD) and Watts Branch (MD) upstream subtributaries with clam biomonitoring. Objective C was to determine long term contaminant bioaccumulation with consecutive clam sampling at a single site. Objective D was to repeat the 2001 contaminant bioaccumulation study at four major Anacostia tributaries. All the studies involved University of the District of Columbia undergraduate biology research students.

METHODOLOGY

For the 2002 studies, 18 - 29mm Corbicula fluminea clams were obtained by wading in the Potomac estuary 5 km below the Anacostia branch, at Fort Foote (MD). Clams were kept cool and dry on blue ice during translocation to Anacostia sites, usually the same day (Table 1). Fort Foote control samples were taken. Shellfish mesh bags or weighted cages with 50-60 clams each were placed at the sites, GPS taken and TidbiT temperature monitors attached at reference sites (Table 1, Fig. 1). For the long-term contaminant bioaccumulation study (PBL) two hundred clams were deployed.

Cages were recovered after a minimum of eight weeks deployment (Roesjadi et al 1984) except for the long term bioaccumulation study. The clam size range, mortality and temperature data if present were recorded. Clams were washed, depurated for 24 hours in three changes of spring water at room temperature, frozen to open shells, shucked, and the tissues refrozen and hand-carried to Severn-Trent Laboratories (STL) in Sparks, MD for chemical analyses. STL filled out chain-of-custody forms and carried out EPA Priority Pollutant analysis of the clam tissues, including 21 pesticides, 29 PCB congenors, 18 PAH's and six metals (As, Cu, Cd, Fe, Zn and Cr). Electronic results were available within five weeks. On 9/20/02 the PBL clam cage was found buried in gravel and all clams were dead, so the long-term study ended early. On 10/25/02 the NEB02 cage was found buried in gravel and clams dead so that sample was lost.

Thirty - 50 clams were analyzed per sample and the Severn-Trent Laboratory analytical variability for clam tissue samples is SD = 0.175(mean) - 1.12 (n = 9) (Phelps 2002). Statistical comparison among contaminant totals was by t test and 95% confidence limits of the mean were (2.05 SD) = 0.37 (mean), the basis for graphical error bars.

RESULTS AND DISCUSSION

TidbiT temperature monitors attached to shellfish bags at the O Streed estuary (OS), Paint Branch Longtern (PBL) and Northwest Branch (NWB) sites indicated water temperatures ranged from a high of 32 deg C to a low of 11 deg. C over the course of the 2002 translocations. This is within the activity range for Corbicula clams (Phelps 1997).

Table 1. Study site dates of clam translocation and collection (recovery) and GPS data.

Site	Date Transl.	Date Collected	GPS
Potomac River Estuary			
Fort Foote MD (FF1)		5/3/02	N38°46.460’, W077°01.770’
Fort Foote MD (FF2)		7/2/02	N38°46.460’, W077°01.770’
DC Estuary			
O Street Outfall (OS)*	5/3/02	6/28/02	N38°52.353’, W077°00.237’
Anacostia Watershed, Watts Branch and subtributaries			
Lower Beaverdam Creek High (LBH)*	5/3/02	6/28/02	N38°54.729’,W076°54.539’
Indian Creek Low (ICL)	7/2/02	9/15/02	N38°59.623’, W076°55.161’
Indian Creek High (ICH)	8/31/02	10/25/02	N39°01.364’, W076°54.212’
Beaverdam Creek (BDC)	7/2/02	9/15/02	N39°00.968’, W076°53.862’
Paint Branch Longterm (PBL)	7/25/02	8/5, 8/21	N38°58.541’, W076°55.180’
Little Paint Branch (LPB)	5/3/02	6/28/02	N38°59.437’,W076°56.126’
Watts Branch Low (WTL)	8/30/02	10/27/02	N38°53.481’, W076°54.779’
Watts Branch High (WTH)	8/30/02	10/27/02	N38°53.475’, W076°54.870’
Watts Branch (WAT02A)	5/3/02	6/28/02	N38°54.395’, W076°56.942’
Watts Branch (WAT02B)	8/30/02	10/27/02	N38°54.395’, W076°56.942’
Anacostia Watershed, repeat 2001 sites			
Northeast Branch (NEB02)	8/30/02	10/25/02	N38°57.621’, W078°55.583’
Northwest Branch (NWB02)*	8/30/02	10/25/02	N38°56.741’, W076°56.855’
Lower Beaverdam Creek (LBC02)	8/30/02	10/25/02	N38°54.977’, W076°55.985’
Hickey Run Low (HRL02)	8/30/02	10/25/02	N38°54.586’, W076°57.710’

* TidbiT temperature monitors attached to cages

GPS locations of clam translocation sites in the Anacostia estuary and watershed mapped by ArcView (Table 1, Fig. 1).

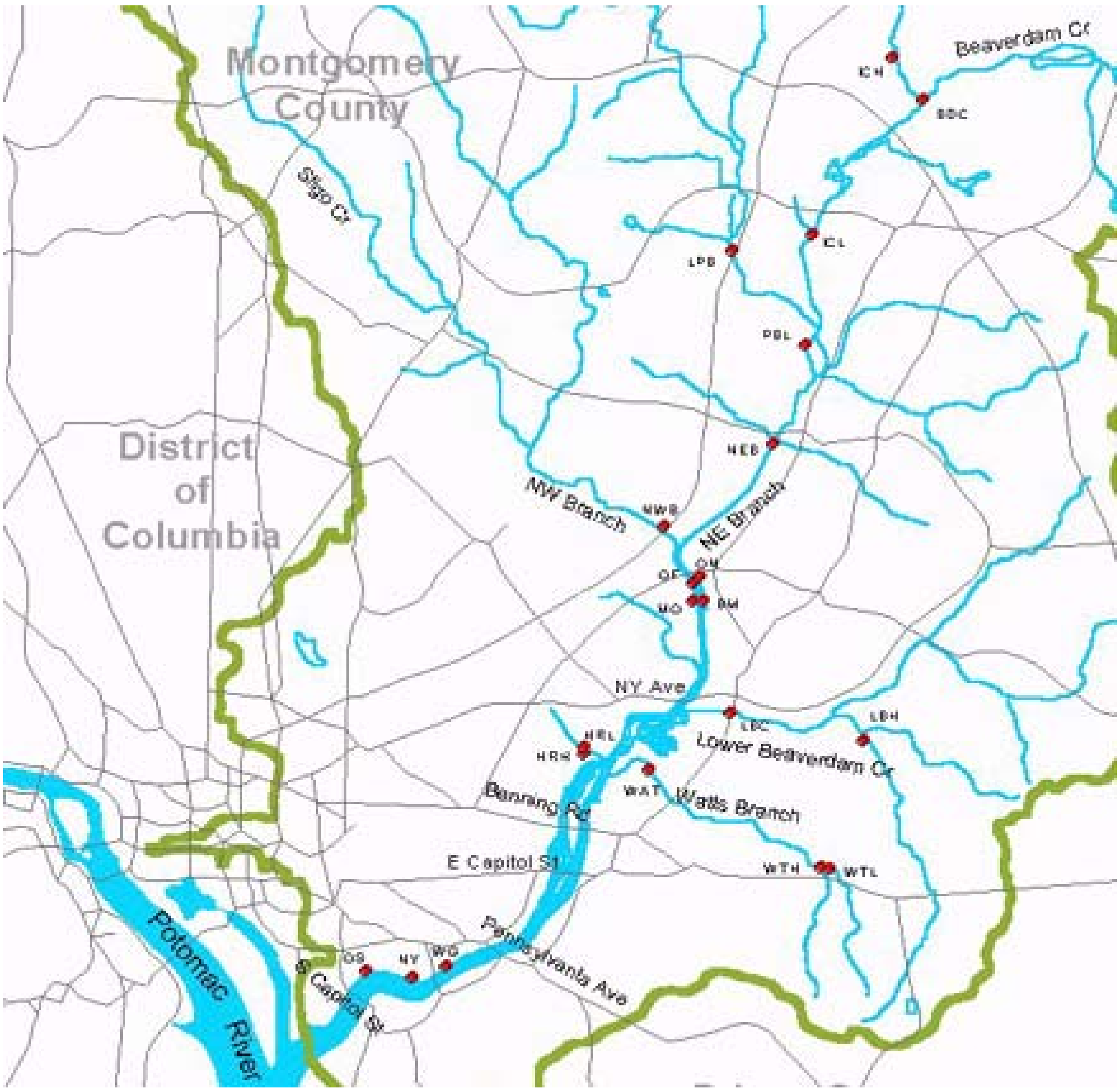

Figure 1. Locations of Corbicula clam translocation sites in the Anacostia watershed (red marks).

In cages that were not buried the percent clam survival ranged from 34 to 100 percent (Table 3). Higher mortality was found at Watts Branch Low (WTL), O Street Outfall (OS) and Watts Branch (WAT02A) and Beaverdam Creek.

Table 2. Percent survival of caged clams at Anacostia watershed sites.

WTL	OS	WATA	BDC	LPB	LBH	LBC	WTH	HRL02	ICH	WATB	PBL	ICL	NWB02
34	51	66	79	95	95	95	97	97	99	100	100	100	100

The clam tissue total contaminant levels at the Potomac River estuary Fort Foote site are compatible with the Potomac ecosystem which has been called a Chesapeake Bay recovery success (Phelps 1984). The highest 2001and 2002 Fort Foote sample contaminant totals (*) were selected as references for comparison with Anacostia watershed clam totals (Table 3).

Table 3. Clam tissue contaminant totals (ug/Kg dry weight) in 2001 and 2002 at the Potomac Fort Foote reference site.

	4/01	7/01	9/01	FF1(5/02)	FF2(7/02)
T Metals x .01	94*	74	46	77	71
T PAHs	388	397	361	391	598*
T Pesticides	100*	70	53	48	30
T PCBs	174*	131	97	79	73

* Selected reference totals.

Objectives A and B.

Clams translocated 5/3/02 - 6/28/02 (8 - 9 weeks, Table 1) included a set suspended directly in the large Washington, DC O Street Sewage Pump Station Outfall (OS) entering the lower third or basin part of the Anacostia estuary (Fig. 1). Studies of Anacostia sediment contaminants have found “hot spots” in this region of the Anacostia and implicated the O street outfall as a major source of contaminants (Velinsky and Ashley 2001). Clam survival was relatively low (Table 1). Tissue contaminant totals were not significently different among clams at other sites in the lower basin third of the Anacostia estuary (Navy Yard and Washington Gas Light, Phelps 2002) (Fig. 1, Fig. 2, Table 4, Table 6).

Table 4. Contaminant totals in clam tissues 5/3/02 - 6/28/02 (ug/Kg dry weight).

	FF1	OS	WATA	LPB	ICL	LBH
T Metals x .01	77	47	62	65	66	108
T PAHs	391	1262*	4612*	905*	2789*	2183*
T Pesticides	48	124	103	76	97	72
T PCBs	79	175	130	131	86	88

* Statistically exceeding Potomac (Fort Foote) reference (Table 3) ($p < .05$)
Key: FF1 (Fort Foote Reference 1), OS (O Street Outfall), WATA (Watts Branch tributary), LPB (Paint Branch subtributary of the Northeast Branch), ICL (Indian Creek Low subtributary of the Northeast Branch), LBH (Lower Beaverdam High subtributary of Lower Beaverdam Creek).

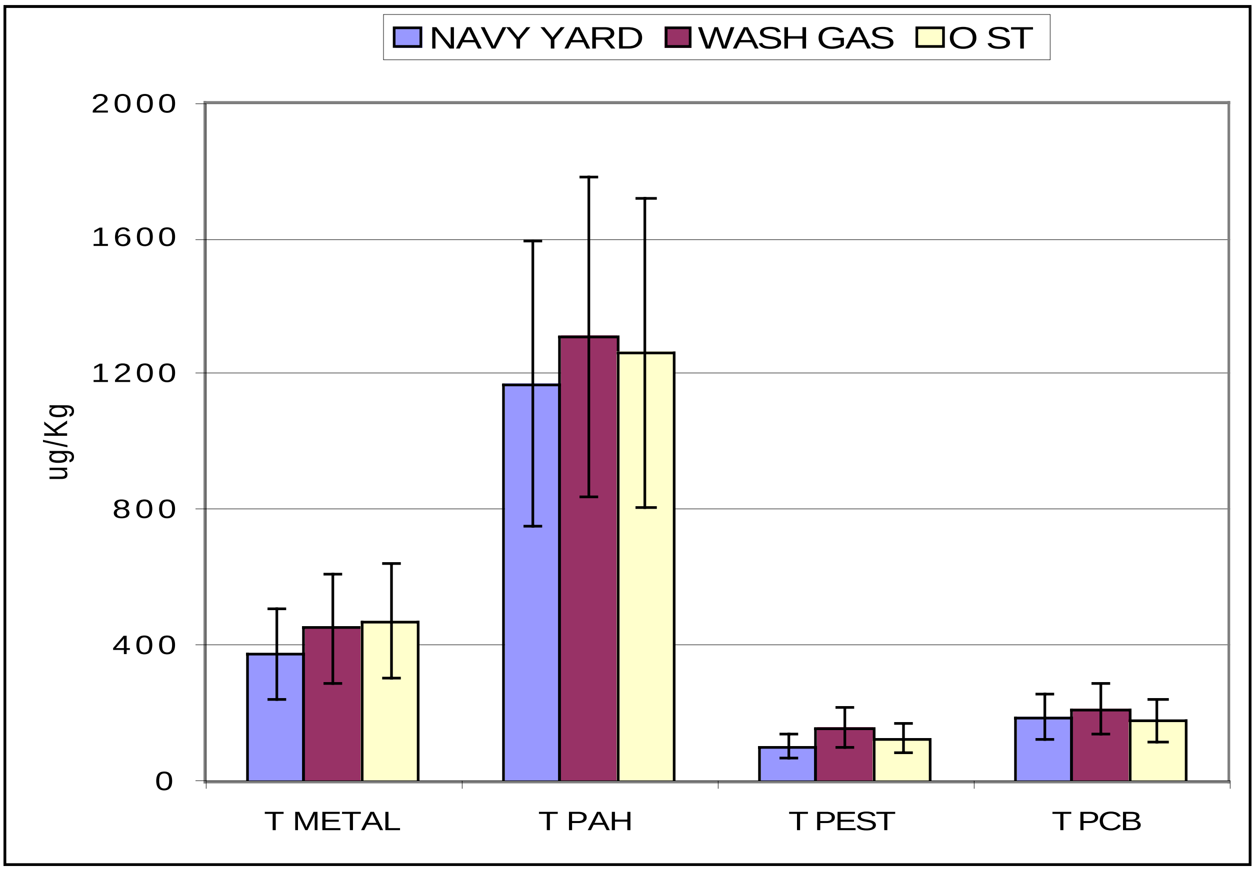

Figure 2. Contaminant class total concentrations in clams translocated to lower Anacostia estuary basin sites.
Key: FF (Fort Foote, Potomac), Wash Gas (Washington Gas Light), O St. (O Street Sewage Pumping Station). Error bars are 2.05 x analytical standard deviation.

Clams translocated to tributary sites 8/30/02 and recovered 10/25-27/02 (8 - 9 weeks) were analyzed by Severn-Trent laboratory as before (Table 5) except at WTL and WTH sites where there was only sufficient tissue for pesticide and PAH analyses.

Table 5. Contaminant totals (ug/Kg dry weight) in clam tissues 8/30 - 10/25/02.

	FF2	NWB02	LBC02	ICH	BDC	HRL02	WATB	WTL	WTH	PBL1	PBL2
t Metals x.01	71	100	166*	96	90	79	94	--	--	73	73
t PAHs	598	933*	1345*	2581*	431	1888*	1193*	1576*	1126*	180	88
t Pesticides	30	58	68	46	42	63	106	225*	98	50	43
t PCBs	73	64	326*	72	59	126	115	--	--	128	107

* Statistically exceeding Potomac (Fort Foote) reference (Table 2) (p < .05)

Key: FF2 (Fort Foote 8/30), NWB02 (Northwest Branch 02), LBC02 (Lower Beaverdam Creek 02), ICH (Indian Creek High), BDC (Beaverdam Creek), HRL02 (Hickey Run Low 02), WATA (Watts Branch 6/02), WATB (Watts Branch 10/02), WTL (Watts Branch Low), WTH (Watts Branch High), PBL1 (Paint Branch Longterm 8/6/02), PBL2 (Paint Branch Longterm 8/21/02)

<u>Northeast Branch Contaminants and Subtributaries</u>

The highly urbanized Northeast Branch tributary contributes about 45% of Anacostia river input (Warner et al. 1997). The 2001 Northeast Branch clams had the highest total pesticides of any tributary (Table 6) (88% chlordane, Fig 7). In 2002 this high pesticide level was not found in Northeast Branch upstream subtributaries: LPB coming from the University of Maryland, ICN coming from the Beltsville Industrial Center and BDC coming from the USDA Beltsville Agricultural Research Center (Table 4, Table 5, Fig. 1, Fig. 3, Table 6).

Table 6. Repeated Priority Pollutant totals in Anacostia tributary clams among 2001 (Phelps 2002) and 2002, and Watts Branch on 6/28/02 and 10/25/02.

	NWB01	NWB02	NEB01	LBC01	LBC02	HRL01	HRL02	WATA	WATB
tMetals(x.01)	66	100	73	189*	166*	50	79	62	94
tPAHs	637	933*	1442*	855*	1345*	785^	1888*^	4612*^	1193*^
tPesticides	77	58	740*	295*^	68^	42	63	103	106
tPCBs	83	64	187	666*	326*	97	126	130	115

* Statistically exceeding Potomac (Fort Foote) reference level (Table 2) (p < .05)

^ Statistically different among 2001 and 2002 concentrations (p < .05)

Key: NWB (Northwest Branch 01,02), NEB (Northeast Branch 01), LBC (Lower Beaverdam Creek 01, 02), HRL (Hickey Run Low 01,02), WAT (Watts Branch, 6/28/02, 10/25/02).

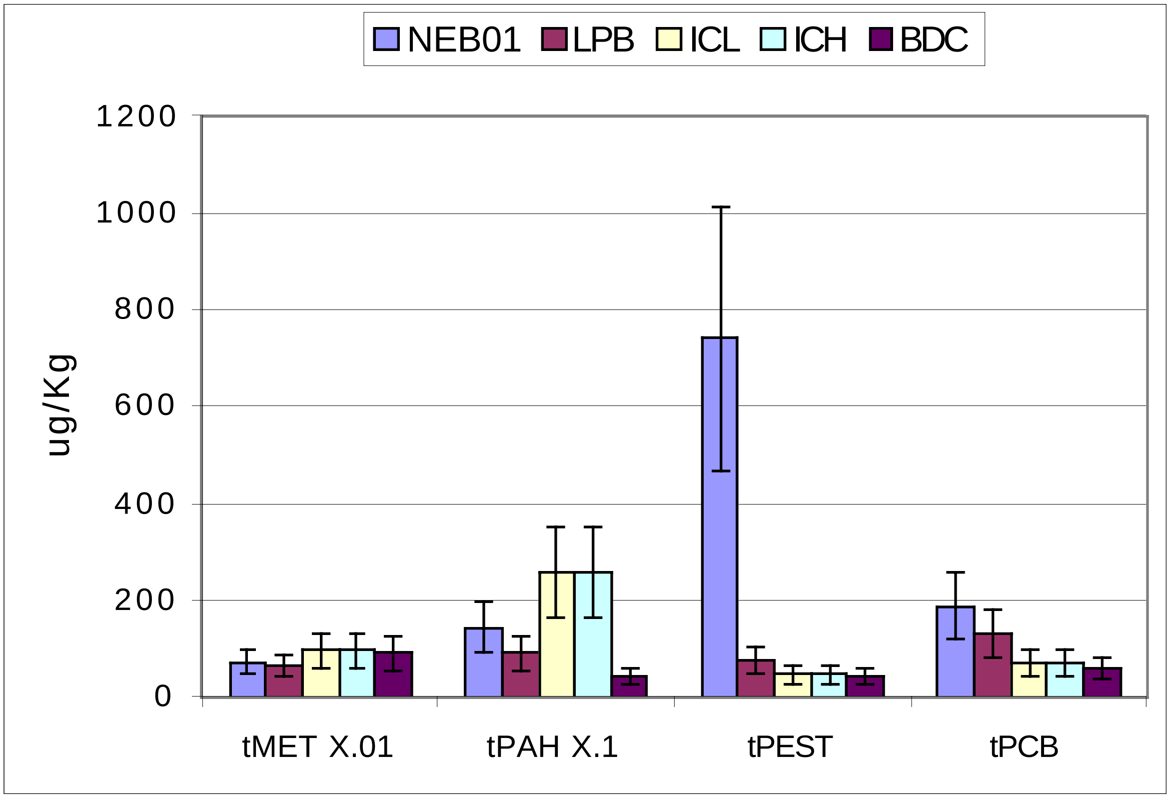

Figure 3. Clam contaminant concentrations in the Northeast Branch and subtributaries.
Key: NEB01 (Northeast Branch in 2001), LPB (Lower Paint Branch), ICL (Indian Creek Low), ICH (Indian Creek High), BDC (Beaverdam Creek) (Phelps 2002)

<u>Lower Beaverdam Creek Contaminants and Subtributaries</u>

Lower Beaverdam Creek clams significantly exceeded Potomac reference values in 2001 for total metals, tPAHs, tpesticides and tPCBs and all but tpesticides in 2002 (Table 6). Clams in the one subtributary examined (LBH) had only tPAHs exceeding reference (Fig. 1, Table 4).

<u>Watts Branch Contaminants and Subtributaries.</u>

Although Watts Branch is a relatively small tributary contributing about 3% of total Anacostia tributary input, the clams recovered on 6/28/02 (WATA) had the highest tPAH bioaccumulation of any site (Table 6). The 6/28 PAH profile was high in low-molecular-weight PAHs, especially napthalenes (Fig. 4). The 10/27 WATB tPAH clam accumulation had fallen by 74%. The high WATA 6/28 tPAH may have been from spring runoff or a source of low-molecular-weight PAHs dispersed by 10/27. There was no statistically significant difference in total metals, pesticides or PCBs among WATA and WATB clams (Table 6).

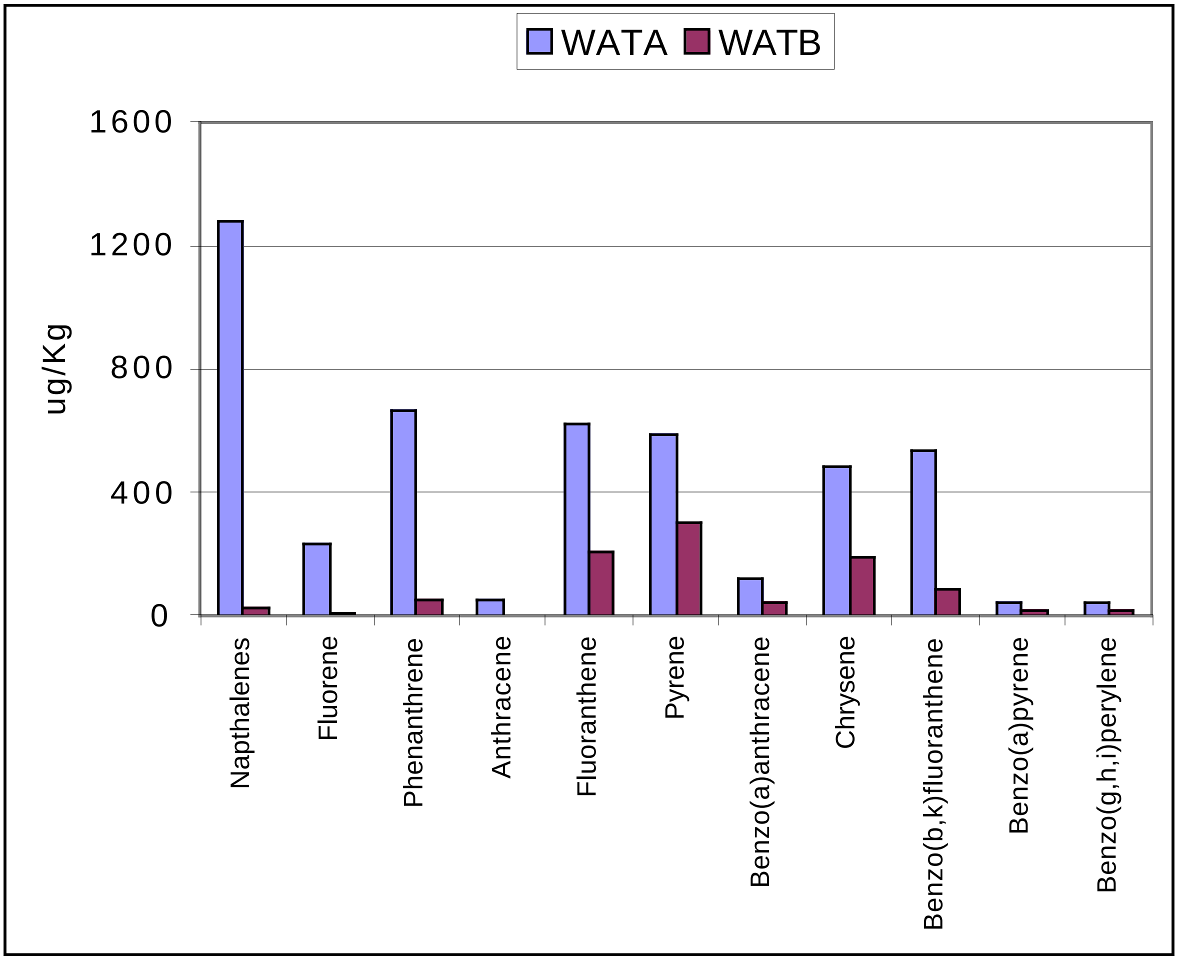

Figure 4. PAH congenors in Watts Branch clams collected 6/28/02 (WATA) and 10/2702 (WATB).

<u>Chlordane and PCBs in the Anacostia watershed.</u>

Chlordane is one of two Anacostia fish tissue contaminants responsible for the fishing advisory and a pesticide shown to cause liver and nerve damage. Chlordane use except for termite control was banned by EPA in 1983, and all use was banned in 1988. Chlordane in clams exceeded the FDA fish consumption chlordane action level of 100 ug/Kg. at the 2001 Northeast Branch site (NEB01, 240 ug/Kg) and 2002 Watts Branch Low site (WATL,172 ug/Kg) (Fig. 5).

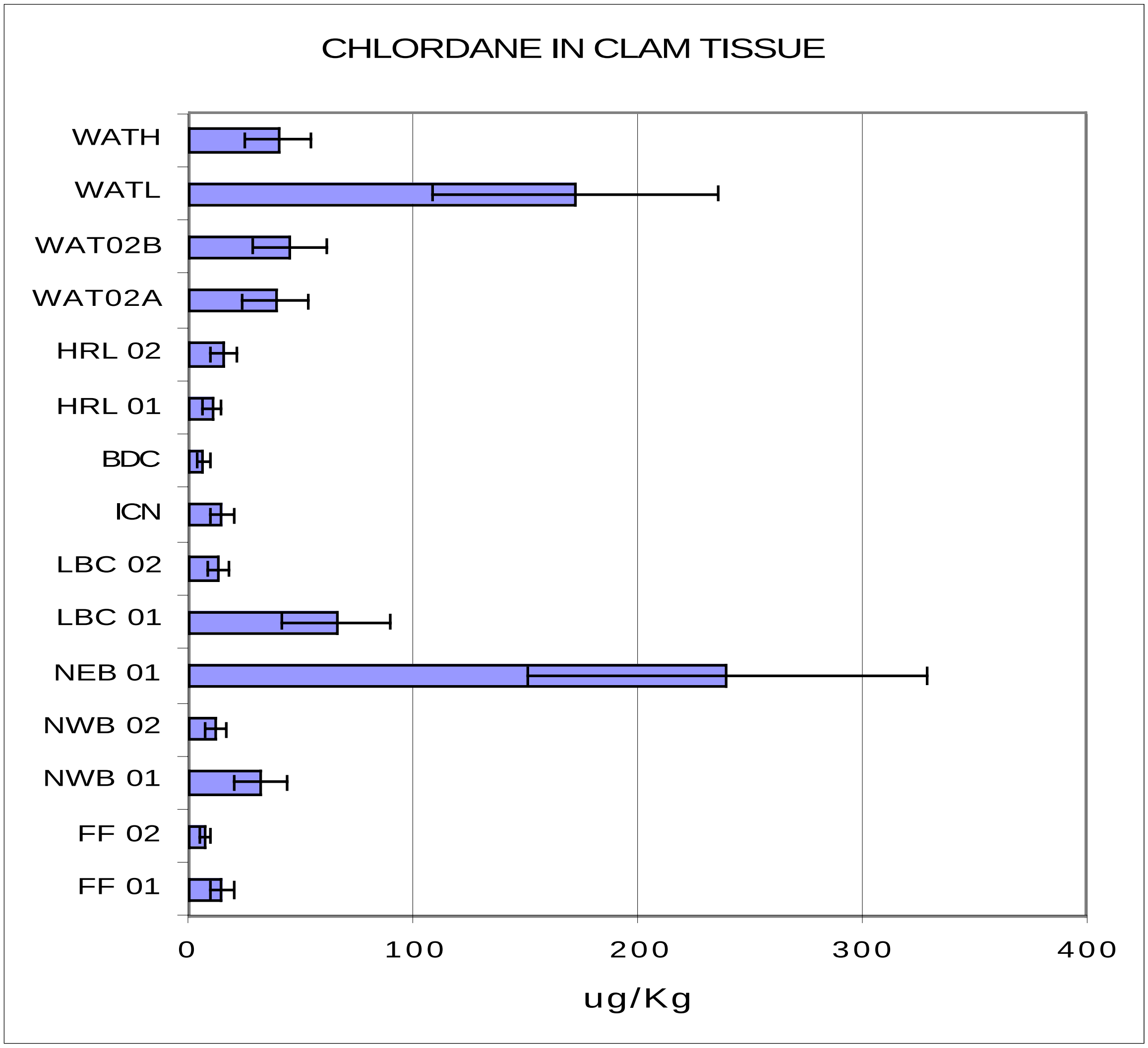

Figure 5. Chlordane bioaccumulation by clams at 2001 and 2002 Anacostia sites and reference. Key: FF1,2 (Fort Foote reference); NWB01,02 (Northwest Branch in 2001, 2002); LBC01,02 (Lower Beaverdam Creek); ICN (Indian Creek North subtributary of the Northeast Branch); BDC (Beaverdam Creek subtributary of the Northeast Branch); HRL01,02 (Hickey Run Low); WATA,B (Watts Branch); WTL (Watts Branch Low subtributary of Watts Branch); WTH (Watts Branch High subtributary of Watts Branch).

PCB contaminant levels in Anacostia fish tissues are also responsible for the Anacostia fishing advisory (Velinsky and Cummins 1994). PCBs have 209 congenors, produce health effects, can bioaccumulate to high levels in aquatic animals and have not been manufactured in the US since 1977 (Safe 1994). Total PCBs in clams at Lower Beaverdam Creek exceeded the FDA food action level of 200 ug/Kg in 2001 and 2002 (Table 6). The PCB congenor homologs in clams at tributary sites with increased tPCBs (Table 4, Table 5) showed PCBs in Lower Beaverdam Creek clams had high levels of volatile tri, tetra and penta homologs (Fig. 6).

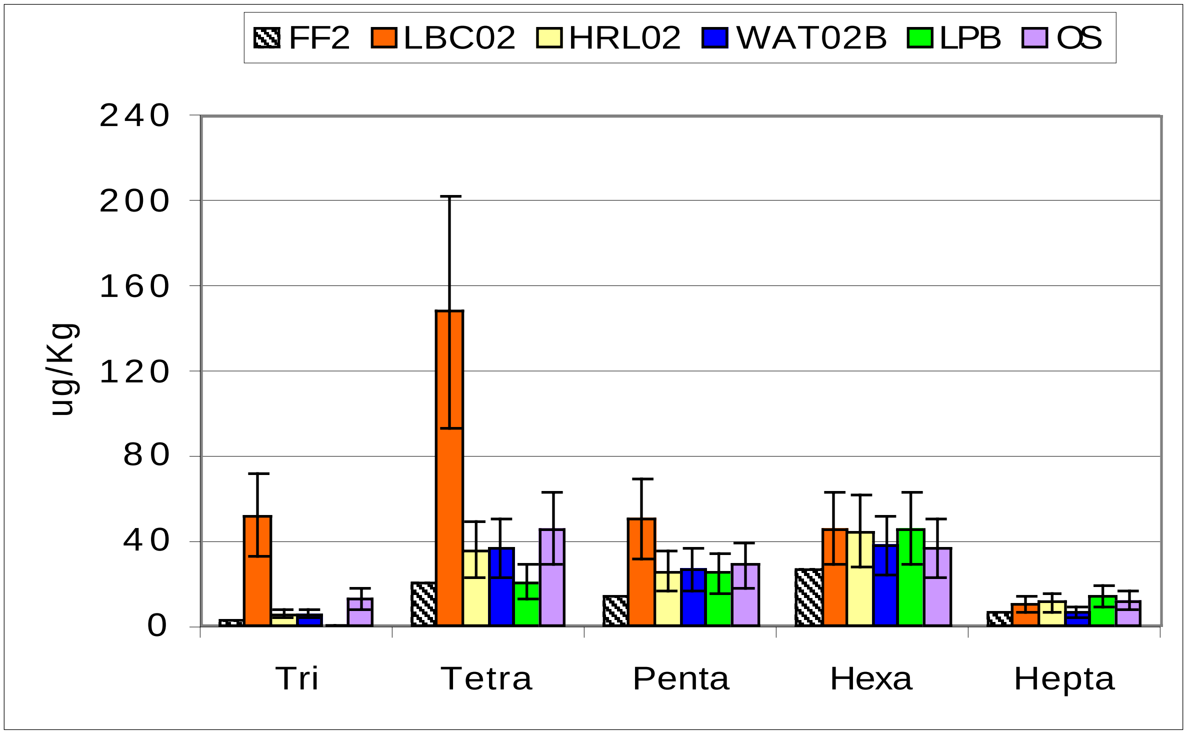

Figure 6. PCB homolog groups in clams at the Potomac Fort Foote site (FF) and at Anacostia watershed sites with significently increased total PCBs (2002): Lower Beaverdam Creek (LBC02), Hickey Run Lower (HRL02) and Watts Branch (WAT2).

Objective C. Long-term contaminant bioccumulation.

Clams sampled sequentially at the Lower Paint Branch site had statistical increases over original Potomac clams in levels of tPAHs, tPCBs and tPesticides at 11 and 27 days, but not tMetals which seldom exceed the Potomac reference level (Table 7).

Table 7. Consecutive contaminant accumulation (ug/Kg dry weight) in clam tissues at 11 and 27 days (Lower Paint Branch) and at the Potomac reference site FF2.

	FF2	11 days	27 days
T Metals x.01	71	73	73
T PAHs	598	1804*	882*
T Pesticides	30	50*	43*
T PCBs	73	128*	107*

* Statistically greater than original Potomac (Fort Foote) clams ($p < .05$)

Objective D. Repeat of the 2001 clam contaminant study at tributary sites.

Clam tissue contaminant totals were compared among 2001 and 2002 at three major tributary sites, Northwest Branch (NWB), Lower Beaverdam Creek (LBC) and Hickey Run (HRL) , and among Watts Branch tributary samples in 2002 (Table 6).

CONCLUSIONS

In the lower Anacostia estuary the contaminant concentrations in clams placed directly in the Washington DC O Street Sewage Pump Station Outfall were not statistically significantly different from concentrations at two other sites in the lower basin in 2001 (Fig. 1, Fig. 2). Stationary Passive Monitoring Device (SPMD) contaminant monitoring in this area had similar results (Pinkney et al., 2003). Tidal mixing apparently prevents contaminant source localization in the lower estuary portion of the Anacostia.

Clams translocated from the freshwater Potomac to sites in the fluvial Anacostia watershed in 2001 and 2002 had significantly increased tPAHs at all sites except the Northwest Branch (2001) and the Beaverdam Creek subtributary of the Northeast Branch. Total pesticide levels were significantly higher than Potomac reference at two sites, higher tPCBs at one site, and higher tmetals at one site (Table 6). This eliminated several tributaries and subtributaries as major sources of contaminants, and implicated others. Specifically, in Lower Beaverdam Creek the Lower Beaverdam High subtributary was not a significent contaminant source (Table 4); in Watts Branch the Watts Branch Low (WTL) subtributary contributed a majority of the chlordane and PAH contamination (Table 4); at the Northeast Branch tributary (NEB) the Beaverdam Creek subtributary (BDC) did not contribute significent bioavailable contaminants or pesticides although draining the large Beltsville Agricultural Research Center which has a CERCLA site (Table 4). However the Indian Creek North (ICN) subtributary from the Beltsville Industrial Center had very high (4X) clam tPAH levels (Table 4). The majority (3 of 4) upstream subtributary sites with significantly increased clam contaminant levels were in Prince Georges County, MD.

Chlordane concentrations (along with PCBs) are responsible for the present Anacostia fishing advisory (Velinsky and Cummins 1994). Chlordane is persistant in soil, slow to break down and not very soluble in water. Because of chlordane's 30 year ban and extensive former use for termite control in this area point sources were not expected. However, the finding of two tributaries/subtributaries (Northeast Branch below Lower Paint Branch and Watts Branch Low) with high clam chlordane levels suggests there may be deposits of chlordane-contaminated sediments eroding into those watersheds. Using Corbicula monitoring it is hoped to more closely define the stream reaches that are the source of chlordane. Finding and remediating these two high-level chlordane sources may be both necessary and sufficient to remove the Anacostia fishing advisory based on chlordane.

Total PCBs in some Anacostia fish species above the FDA action level of 200 ug/Kg are responsible for the fishing advisory. Total PCBs in clam tissue exceeded the FDA food action level at Lower Beaverdam Creek in 2001 and 2002 (Table 6). Lower Beaverdam Creek PCBs were high in volatile low-molecular-weight congenors, suggesting a recent source (Fig. 6). Lower Beaverdam Creek has the highest industrial watershed area of the 13 Anacostia tributaries and is 99% located in Prince George's County (Warner et al. 1997).

Significant increases in contaminant totals were found at Paint Branch Longterm (PBL) site as soon as two weeks after clam translocation. The low levels compared to clams at nearby sites with eight weeks deployment (LPB, ICN) (Table 5) suggested clam tissues had not reached final contaminant concentrations. Completion of this study in 2003 could lead to shortening of the deployment time needed for Corbicula bioaccumulation studies.

Repeating clam monitoring at three tributary just-above-tide sites in 2001 and 2002 and the Watts Branch tributary in 2002 found 10 of 16 contaminant totals statistically similar ($p < .05$). (Table 4, Table 5). All Northwest Branch clam contaminant totals except metals showed no signficant difference among 2001 and 2002. Lower Beaverdam Creek had signficant changes in tPesticides and tPCBs totals among 2001 to 2002 and tPCBs remained the highest of any tributary. At Hickey Run, entirely in DC, there was signficant increase in tPAH's in 2002. Hickey Run has a history of episodic petroleum releases. At Watts Branch the June 2002 clams had signficant higher tPAHs with low-molecular-weight PAHs not found in the October sample. The June tPAH peak may have been due to a spill or spring runoff. In general the 62% statistical similarity among 2001 and 2002 tissue contaminant totals suggests consistent as well as episodic tributary contamination can be detected by Corbicula biomonitoring.

The advantages of using the hardy freshwater Asiatic clam (Corbicula flumina) to locate pollutant sources in watersheds are similar to the use of marine mussels in the worldwide Mussel Watch program to monitor coastal pollutants (Crawford and Luoma 1993, O'Connor and Beliaeff 1995, Sericano 2000, Chase 2001). Shellfish can accumulate suspended and dissolved bioavailable water contaminants without detoxicification or elimination (Dougherty and Cherry 1988). Shellfish can be translocated to specific locations for periods of weeks or months to monitor bioavailable contaminants in aquatic environments. Although the Zebra mussel (Dreissena polymorpha) has been used to monitor freshwater contaminants (Cope et al.1999) it is not yet found in the Potomac river watershed. The Asiatic clam is naturalized in most US states, found on several continents (Asia, North and South America, Europe) and the most common freshwater mollusc species worldwide. Corbicula has been used and deployed for contaminant biomonitoring instead of using endangered local mollusc species (Hartley and Johnston 1983, Elder and Mattraw 1984, Crawford and Luoma 1993, Colombo et al. 1995). The present study demonstrates the usefulness of the translocated Asiatic clam in finding major sources of EPA priority pollutants in an urban watershed. This 'Clam Watch' program can be an effective screening methodology for freshwater watersheds that is far more rapid and less expensive than intensive water monitoring methods that can be employed for more thorough investigations. Although the present focus of Anacostia remediation is on sediments (AWTA 2002), locating and reducing the watershed sources of contaminants must be a priority.

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