Report for 2003DC34B: Sources of Bioavailable Toxic Pollutants in the Anacostia Watershed (Part III)

There are no reported publications resulting from this project.

Report Follows

Sources of Bioavailable Toxic Pollutants in the Anacostia Watershed (Part 111)

Final Report to the DC Water Resources Research Center Dr. Harriette L. Phelps June 8, 2004

ABSTRACT

This report summarizes results of the first three phases of this study on finding watershed pollutant sources to DC's Anacostia River freshwater estuary. EPA Priority Pollutants (PAHs, PCBs, Aroclors and Pesticides) and seven metalsCd, Cu, Cr, Fe, Pb, Zn) were biomonitored in the Anacostia River estuary and its five major tributaries using Asiatic clams *(Corbicula fluminea)* translocated from the nearby Potomac River estuary. Biomonitored sites included four Anacostia estuary sites and 16 tributary sites: two in DC and 14 in Maryland. Total metals (As, Cd, Cu, Cr, Fe, Pb, Zn) in clam tissue exceeded reference (Potomac) concentration at one tributary site. Total PAHs (18) in translocated clam tissues significantly exceeded reference Potomac clams at all four Anacostia River sites and 14/18 tributary sites. Total PCBs (26 congenors) and Aroclors (4) in translocated clam tissue significantly exceeded reference at all Anacostia estuary sites, the lower Northeast Branch and two sites in one tributary, Lower Beaverdam Creek. Total pesticides (20) in translocated clam tissue significantly exceeded reference in three tributaries and including over 80% chlordane in Watts Branch and Northeast Branch tributaries. All but one MD tributary site with tPAH, tPCB and tpesticide levels significantly exceeding reference were in the Northeast Branch (Prince George's County) which has a number of industrial parks. Translocated Asiatic clams reached maximum tissue contaminant load in two weeks.

INTRODUCTION

The 10 km freshwater contaminated Anacostia River estuary is one of three Areas of Concern in the Chesapeake Bay and listed among America's 10 worst rivers. In contrast to the confluent healthy Potomac River estuary the Anacostia resident fish (catfish) have a high tumor incidence (Pinkney et al 2000, Washington Post 2004b)) and there are few surviving benthic animals, including *Corbicula* clams (Phelps 1985). In spite of posted fish consumption warnings due to chlordane and PCBs (Velinsky and Cumming 1994) there is fishing in the Anacostia, especially by low-income residents. Planned development of the DC waterfront is increasing interest in the Anacostia (Washington Post 2003). A major suspected source of contaminants has been the contaminated sediments of the Anacostia estuary (Phelps 1983, AWTA 2000). There has been little study of possible tributary sources which may be even more important (Warner et al. 1997, Washington Post 2004a).

Translocation of molluscs for bioaccumulation of water pollutants is considered a significant method for detecting bioavailable low-level variable water contamination (DeKock and Kramer 1994). The *Corbicula* clam is recognized for freshwater biomonitoring because it is nonendangered and can bioconcentrate and store contaminants without chemical alteration or toxic effects (Colombo et al. 1995, Crawford and Luoma 1993, Dougherty and Cherry 1994).

Corbicula clams from the large population in the nearby Potomac river were translocated for biomonitoring to sites in the Anacostia River estuary and watershed. The first research

objective of the present study was to identify upstream tributaries with high levels of bioavailable PCBs and chlordane within the Northeast Branch (MD) and Lower Beaverdam Creek (MD) tributaries, based on previous studies (Phelps 2002, Phelps 2003). The second objective was to find minimum translocation time for maximum contaminant bioaccumulation.

METHODOLOGY

For the translocation studies, 20 - 35 mm Asiatic clams (Corbicula *fluminea)* were collected by sieving the near-shore sandy sediment at Fort Foote (MD) which is on the Potomac estuary 5 km below the mouth of the Anacostia River estuary. The Fort Foote site (FF) is the reference site for clam contaminant levels because of the healthy condition of the freshwater estuarine Potomac there now the second ranking large-mouth bass fishing area in the U.S. and considered a Chesapeake Bay restoration success (Phelps 1994; Orth et al. 1996).

Clams were collected at AM low tide and held cool and dry until placed in shellfish bags or boxes at Anacostia locations within 8 hours. TidbiT continuous temperature monitors were attached to bags at two locations. When clams were recovered they were depurated 24 hours with three changes of spring water, then frozen and thawed to remove tissues. All clams at a site (20-40) were combined for a single tissue sample of over the 60 gm needed for complete analysis. Refrozen tissues were hand-carried to Severn-Trent Laboratories (STL) of Sparks, MD, which forwarded them to Severn-Trent Laboratories of Burlington, VT, for analysis. Tissue samples were analyzed for EPA Priority Pollutants: 20 pesticides, 28 PCB congenors, 18 PAHs, and seven metals (As, Cu, Cd, Cr, Fe, Pb and Zn). Electronic results were available within five weeks. The STL analytical variability was SD = 0.175 (mean)- 1.12 (n = 9) (Phelps 2002). Statistical comparison was by t test and the 95% confidence limits of the mean were calculated as 2.05 SD = 0.36 (mean), used for graphical error bars.
Asiatic clams were collected from the Potomac on 5/24/03 for the long-term bioaccumulation study and placed in the upper end of the Anacostia estuary at Bladensburg Marina (BM) with samples taken at 2,4, 8 and 11 weeks.

Anacostia watershed biomonitoring sites were selected in 2003 to find the tributary origins of high levels of pesticides (chlordane) and PCBs based on previous studies (Phelps 2002, Phelps 2003). For the high pesticides in the Northeast Branch (particularly chlordane) clams were placed at the 2001 Northeast Branch site (NEB03) and just upstream of NEB03 at Riverdale Park (RDP) on 5/24/03. On 10/5/03 clams were placed at a third site in the Northeast Branch tributary slightly further upstream at the entrance of the second order stream Brier Ditch Creek (BDT). For PCBs in Lower Beaverdam Creek, clams were placed on 10/5/03 at the biomonitoring site upstream of LBC on Beaver Road (BVR). Since the first translocation (5/24/03) established that two weeks were sufficient for maximum contaminant accumulation, the second translocation set (BDT, BVR, 10/5/03) was for two weeks. The Fort Foote clams collected for translocation on 10/5/03 were brooding.

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RESULTS

Clams were translocated to six Anacostia sites in 2003 for biomonitoring.

Table l. 2003 biomonitoring site locations (GPS) and dates of clam translocation and collection.

Site	Date Transl.	Date Coll.	GPS
Potomac River estuary			
Fort Foote MD (FF03)		5/24/03	N38o46.460',W077o01.770'
Fort Foote MD (FF03b)		10/5/03	« «
Anacostia River estuary			
Bladensburg Marina (BM2)	5/24/03	6/9/03	N38o57.621',W078o55.583'
Bladensburg Marina (BM4)	5/24/03	6/21/03	« «
Bladensburg Marina (BM8)	5/24/03	7/23/03	« «
Bladensburg Marina (BMI 1)	5/24/03	8/13/03	« «
Anacostia Tributaries			
Northeast Branch (NEB03)	5/24/03	7/28/03	N38o57.621',W078o55.583'
Riverdale Park (RDP)	5/24/03	7/28/03	N38o57.621',W078o56.312'
Brier Ditch Creek (BDT)	10/5/03	10/20/03	N38o58.250',W076o54.909'
Beaver Road (BVR)	10/5/03	10/20/03	N38o55.157',W076o54.362

For the long-term bioaccumulation study, clams collected from Fort Foote (Potomac) on 5/24/03 were placed in the upper Anacostia estuary at the Bladensburg Marina dock (MD) and collected at 2, 4, 8 and 11 weeks for analysis (Table 2, Fig. 1).

Table 2. Long-term clam contaminant bioaccumulation study, Bladensburg Marina.

Date collected	Week (sample)	Temp (deg.C)	S/T	Mortality (percent)	tMetal mg/kg	tPCBs ug/kg	tArocl ug/kg	tPAH lmg/kg	tPest. ug/kg	tChlordane ug/kg
5/24/03	0 (FF03)	15.6		0	88.2	97	128	441	90	29
6/9/03	2(BM2)	19.7	3.96		93.9	137	203	478	148	73
6/21/03	4(BM4)	18.8	3.66		85.9	97	180	460	137	65
7/23/03	8(BM8)	25.1	3.38	13%	31.9	158	255	403	107	68
8/13/03	11(BMl1)	25.5	3.31	29%	66	137	251	336	112	90

Key: S/T= total shell weight/total tissue weight

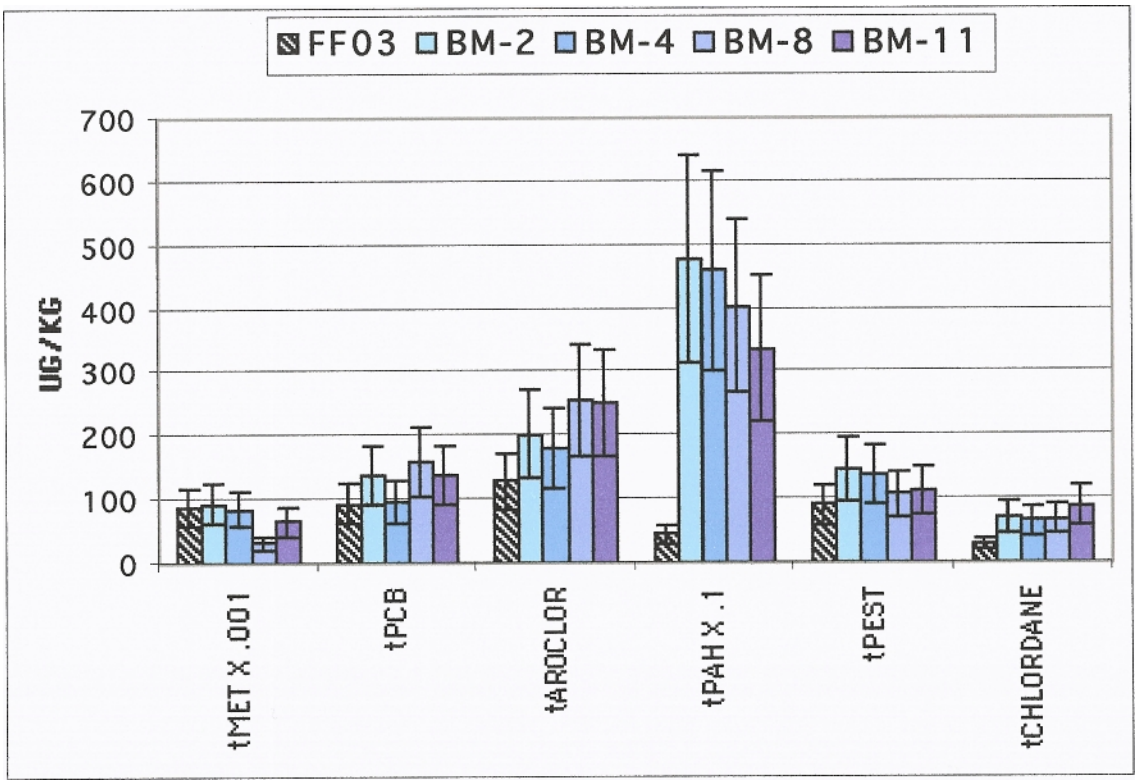


Figure l. Clam tissue EPA Priority Pollutants at Bladensburg Marina +l- 2 SD.

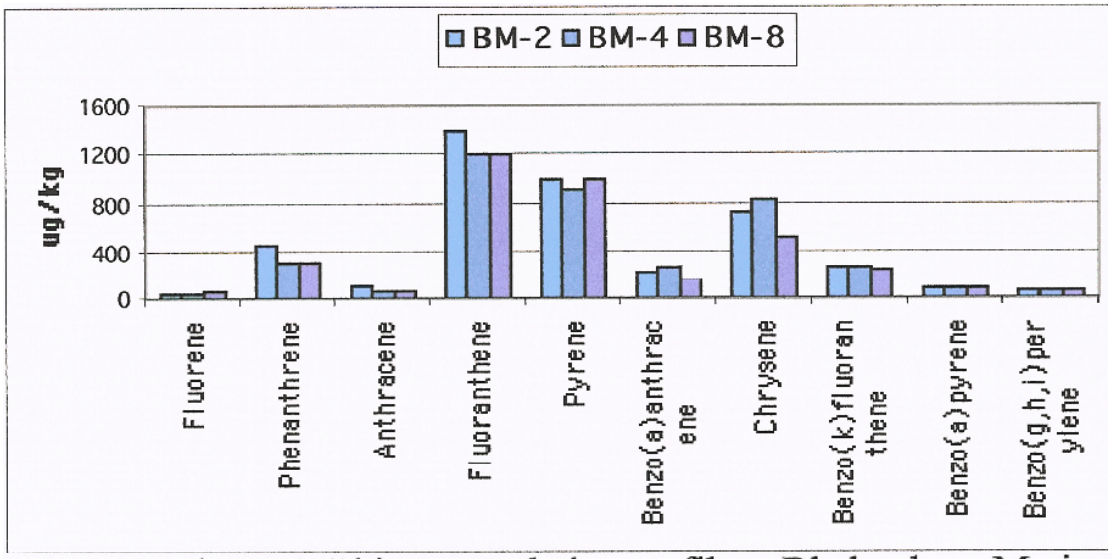


Figure 2. Clam PAH bioaccumulation profile at Bladensburg Marina.

Pesticides in clams translocated to sites in the Northeast Branch tributary (NEB03, RDP and BDT) did not show the high levels of the earlier NEBO l site study (Phelps 2002) (Table 4). However there was a statistically significant increase in chlordane in clams at the Northeast Branch site (NEB03) and just upstream at Riverdale Park (RVP). Chlordane increase was not found in the secondary subtributary of Brier Ditch Creek (BDT) (Table 3, Table 4, Figure 3, Figure 5). Increased total PCBs and pesticides were found in the Lower Beaverdam Creek upstream site of Beaver Road (BVR) where the primary pesticide was DDT (Table 3, Table 4, Figure 3, Figure 6).

Table 3. Clam tissue pollutant totals at Northeast Branch tributary sites (NEB03, RDP, BDT), Lower Beaverdam Creek tributary site (BVR) and the control site at Fort Foote, MD.

Site	tMetal	tPC13	tAroclors	tPAH	tPest	CChoordan
Fort Foote (FF03b)	53	69	256	279	60	23
Northeast Branch (NEB03)	*	118	214	*	72	40
Riverdale Park (RDP)	*	*	203	*	72	39
Brier Ditch Creek (BDT)	49	70	310	419	93	29
Beaver Road (BVR)	61	230	900	601	109	52

Key: * not measured

Figure 4. Anacostia watershed sites where clam tissue total PAH bioaccumulation statistically exceeded reference (Table 4, $p<.05$).

Anacostia watershed sites with clam tPAHs statistically exceeding the Potomac control value

Table 4 summarizes clam tissue contaminant totals at all Anacostia watershed translocation sites for Phases I, II and III. Reference clam tissue contaminant totals for statistical purpose were taken as the average of all the Fort Foote contaminant totals, except where noted.

Table 4. Anacostia site summary of clam survival and tissue contaminant totals (ug/Kg dry weight)

Site, M/D/Y	Survival	tMetals	tPAHs	tPCBs	tPesticides percent x.001
Potomac River Estuary at Fort Foote MD (Control and Collection Site)					
Fort Foote 5/16/99 (MD) (FF)		49	421	46	25
Fort Foote 4/5/01		94	384	173	100
Fort Foote 7/15/01		74	457	131	70
Fort Foote 9/29/01		71	354	97	53
Fort Foote 5/3/02		77	391	79	48
Fort Foote 7/2/02		73	598	73	30
Fort Foote 5/24/03		88	441	94	90
Fort Foote 10/5/03		53	279	69	60
Average		72	415	102	64
Anacostia Estuary Sites					
Bladensburg Marina (MD) (BM)	98	79	2350*	239*	94
Navy Yard (DC) (NY)	98	75	1366*	186*	102
O Street Outfall (DC) (OS)	51	47	1262*	175*	124
Washington Gas (DC) (WG)	97	90	1502*	212*	128
Anacostia Watershed Tributaries, first order streams					
Hickey Run 0 1 (DC) (HRHO1) 97		50	785*	97	42
Hickey Run 02 (DC) (HRH02) 97		90	1888*	59	63
Lower Beaverdarn Creek 01(MD) (LBCO1) 95		189*	855*	666*	295*
Lower Beaverdam Creek 02 (MD) (LBC02) 95		166*	1345*	326*	68
NorthEast Branch 0 1 (MD) (NEBO1) 100		73	1442*	187*	740*
NorthEast Branch 03 (MD) (NEB03) 42		--	--	118	72
NorthWest Branch 01(MD) (NWBO1) 100		66	637	83	77
NorthWest Branch 02 (MD) (NWBO1) 100		100	933*	64	58
Watts Branch A 02 (DC) (WATA) 66		62	4612*	130	103*
Watts Branch B 02 (DC) (WATB) 100		94	1193*	115	106*
Anacostia Watershed Subtributaries, second order streams					
Beaverdarn Creek (MD) (BDC) 79		90	431	59	42
Beaver Road (MD) (BVR)		61	601	230*	109*
Brier Ditch Creek (Mm) (BDT)		49	419	49	93
Indian Creek High (MD) (ICH) 99		96	2581 *	126	63
Indian Creek Low (MD) (ICL) 100		66	2789*	86	97
Lower Beaverdam Creek High (MD) (LBH) 95		108	2183*	88	72
Lower Paint Branch (MD) (LPB) 95		65	905*	131	76
Paint Branch Longterm 1 (MD) (PBL) 100		73	1804*	128	50
Paint Branch Longterm 2 (MD) 100		73	882*	107	43
Riverdale Park (MD) (RDP)		--	--	72	39
Watts Branch High (MD) (WATH) 97		--	1126*	--	98
Watts Branch Low (MD) (WATL) 34		--	1576*	--	225*

Selected Fort Foote Reference contaminant levels

* >statistically exceeding Reference average ($p < .05$)

Figure 4. Anacostia watershed sites where clam tissue total PAH bioaccumulation statistically exceeded reference (Table 4, $p<.05$).

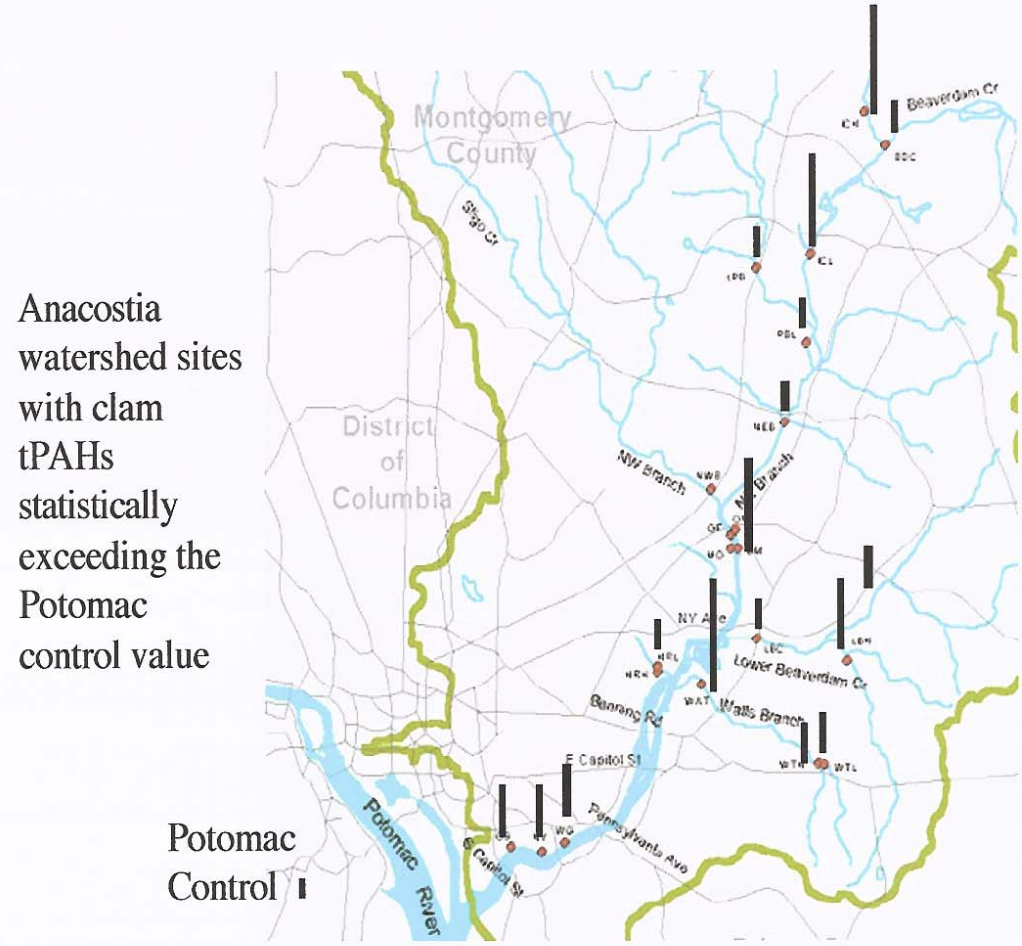


Figure 5. Anacostia watershed sites where clam tissue total pesticide bioaccumulation statistically exceeded reference (Table 4, $p<.05$).

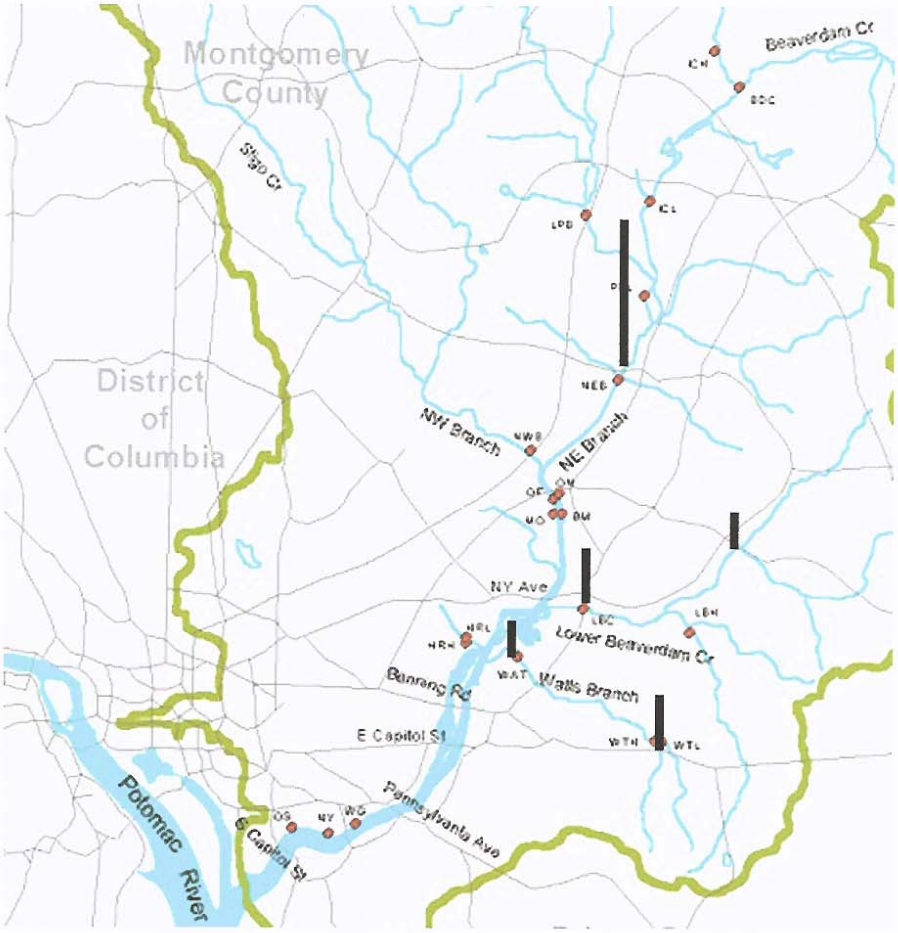
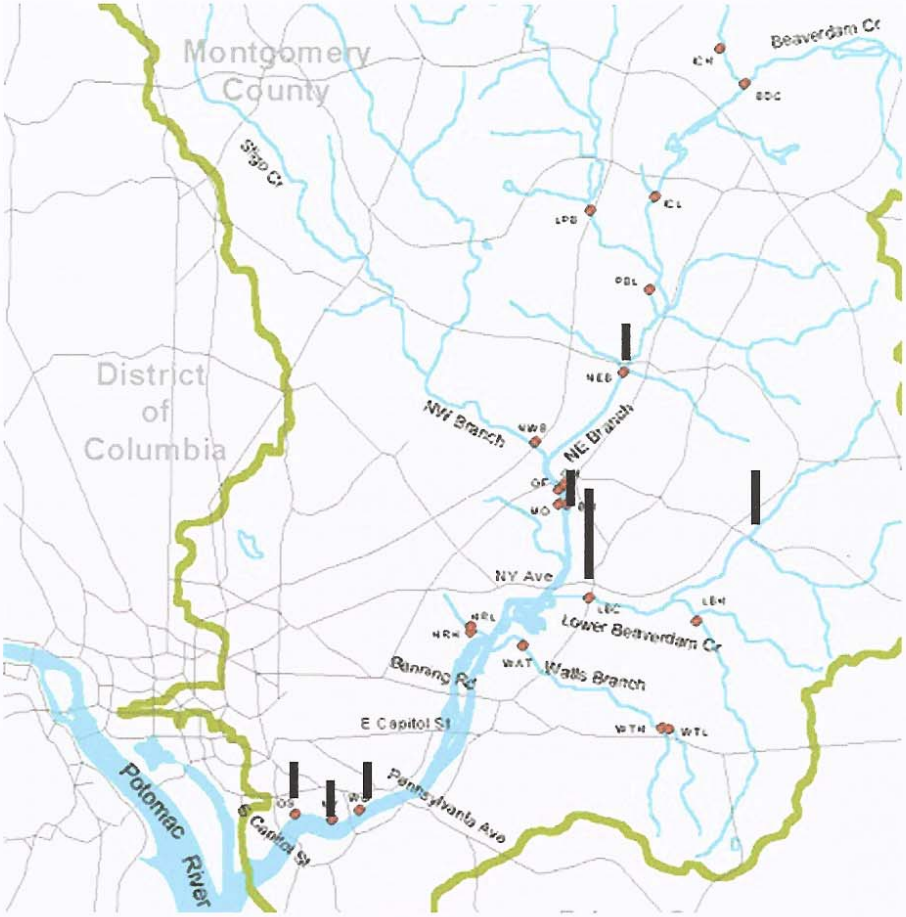


Figure 6. Anacostia watershed sites where clam tissue total PCB bioaccumulation statistically exceeded reference (Table 4, $p<.05$).



DISCUSSION AND CONCLUSIONS

Asiatic clams placed in the upper Anacostia River estuary at Bladensburg Marina showed no statistical difference in total tissue concentrations of PCBs, Aroclors, PAHs, pesticides and metals from 2 to 11 weeks. Rapid bioaccumulation might be expected from the *Corbicula fluminea* clearance rate which is the highest of any clam (Laritsen 1986), and similar to the oyster which shows a PAH accumulation plateau in 2 to 4 weeks (Huggett e.a. 1985). Both mollusc species produce pseudofeces and can filter continuously. Compared to reference (Potomac) clam contaminants, the Bladensburg Marina clams had no significant increase in total metals and only a slight increase in total PCBs, Aroclors or pesticides over the 11 weeks deployment. The clams did have significant increases in chlordane and total PAHs, which were primarily 4-ring PAH pyrogenic combustion byproducts. Over the 11 weeks deployment the clams had decreasing shell/tissue ratio and increasing mortality which suggested both growth and stress. It was decided to use a two week bioaccumulation time for all future studies.

Total metal levels in translocated clams did not significantly exceed levels in reference Potomac clams at all but one site. At the lowest Lower Beaverdam Creek site (LBC) just downstream from a recycling center on Addison Road iron (Fe) levels exceeded control.
Clams placed at the lowest Northwest Branch site (NWB) just above head of tide in 2001 had no contaminant bioaccumulation totals exceeding Potomac reference values, and in 2002 only had low tPAH concentration exceeding reference. The Northwest Branch is in Montgomery County, contributes about 32% of Anacostia tributary input, and is considered relatively uncontaminated (Warner et al 1997).
The present study focussed on upstream sites as possible sources of the chlordane and PCBs responsible for the fishing advisory. High chlordane levels in clams had been found in earlier studies at the lowest Northeast Branch tributary site (NEB), and at lower (WAT) and upper (WBL) Watts Branch tributary sites (Phelps 2002). Elevated chlordane at the Bladensburg Marina estuary site (BM) downstream from the confluence of the Northeast and Northwest branches is reported in the present study. Upstream Northeast Branch subtributary studies have not found chlordane bioaccumulation in clams placed at Paint Branch (PBL) or Indian Creek (ICL) sites (Phelps 2003), or Riverdale Park (RVP) or Brier Ditch Creek (BDT) sites (present study Table 3). The Northeast Branch in Prince George's County contributes about 45% of Anacostia tributary input (Warner et al 1997). Finding the source of Northeast Branch chlordane should be an objective of more study.

Previous Anacostia watershed translocation studies have found high clam tissue PPCBs exceeding FDA food action levels at the lower end of Lower Beaverdam Creek site (LBC). Significantly increased pesticide (DDT) and metal (Fe) levels in clams were also found at LBC. Lower Beaverdam Creek contributes about 12% of Anacostia tributary flow and has the greatest percent industrial area of the Anacostia tributaries (Warner et al 1997). In the present study,

clams placed in Lower Beaverdam Creek at the upstream Beaver Road site (BVR) showed significant accumulation of low-molecular-weight PCBs. BVR is upstream from several industries on Addison Road but downstream from Ardwick Industrial Park. Additional Lower Beaverdam Creek upstream sites should be explored for PCBs.

Bioavailable total PAHs (18) in translocated clams significantly exceeded reference Potomac clam levels at all four Anacostia River estuary sites, high and low, and 14/18 tributary sites. PAHs are known to be carcinogenic, transported by sediments and are probably the major cause of fish tumors and the reduced benthic fauna of the Anacostia River estuary. PAHs have a number of pyrogenic and petrogenic carbon origins. High pyrogenic PAHs in translocated clams were found at sites downstream from some industrial parks of Prince George's County, MD such as the Indian Creek High site (ICH) downstream from Beltsville Industrial Park and the Beaver Road site (BVR) downstream from Ardwick Industrial Park. PAHs were not an object of the present study but should be examined further.

Biomonitoring by translocated Asiatic clams in the Anacostia River watershed has identified specific tributaries as contributors of pollutants important for the Anacostia fishing advisory, and also located tributary sources of pollutants associated with toxic River sediment. These findings could be used as guidelines for more intensive monitoring leading to remediation actions for watershed sources of Anacostia River contamination.

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PRESENTATIONS:

9/15/03 "Finding sources of PAHs, PCBs and pesticides to the Anacostia estuary, DC, using Asiatic Clam (Corbicula *fluminea)* Translocation." Poster Presentation: Estuarine Research Federation meeting, Seattle, WA. Abstract
3/25/04 "Biomonitoring the Anacostia Watershed for Pollutants" Olunbunmi Adekanye, Clemantine Assi, Moina Cook, Nicole McCrea, Danell Sorinmade and Harriette Phelps. Poster Presentation: Atlantic Estuarine Research Society, Norfolk, VA. Abstract
4/22/04 "Biomonitoring the Anacostia Watershed for Pollutants" Olunbunmi Adekanye, Clemantine Assi, Moina Cook, Nicole McCrea, Danell Sorinmade and Harriette Phelps. Poster Presentation: Chesapeake and Potomac Regional Chapter (CPRC) of the Society for Toxicology and Chemistry, Salisbury, MD.

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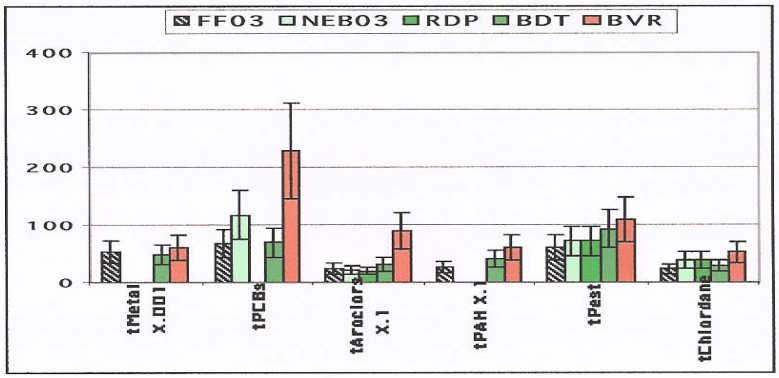

Figure 3. Clam tissue contaminant totals at 2003 Anacostia watershed sites, +/- 2 SD. Key: FF03b (Fort Foote Reference site), NEB03 (Northeast Branch), RDP (Riverdale Park), BDT (Brier Ditch Creek), BVR (Beaver Road).