Heavy Metal, Polychlorinated Biphenyl, and Pesticide Levels in Oysters *(Crassostrea virginica)* 1979 Maryland Oyster Spat Survey

Office of Environmental Programs

Maryland

Department of Health and

Mental Hygiene

HEAVY METAL, POLYCHLORINATED BIPHENYL, AND PESTICIDE LEVELS IN OYSTERS *(Crassostrea virginica)* 1979 MARYLAND OYSTER SPAT SURVEY

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MARYLAND DEPARTMENT OF
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ABSTRACT

Maryland's Office of Environmental Programs began participating in the annual oyster spat survey sponsored by the University of Maryland's Sea Grant Program in the fall of 1979. Oyster samples were collected from 48 sites in the Chesapeake Bay and its tributaries and analyzed for heavy metal, PCB and pesticide levels. This effort was initiated to create a continuous record of the levels of these substances in oyster tissues on a broad Bay wide scale in a small time frame. Ranges, medians, and means and standard deviations were determined for the entire Chesapeake Bay and for some major river systems. Sub-basins were further divided and heavy metal, PCB and pesticide means for different areas determined. Trends suggested by the data were discussed and as the data base is expanded each year it is expected that the significance of some of these trends may be determined.

INTRODUCTION

Purpose of Study

The University of Maryland Sea Grant Program sponsors an annual oyster spat survey cruise to determine recruitment trends for Chesapeake Bay oyster populations. Participants include academic institutions, government agencies, and private citizen groups. Personnel from Maryland's Office of Environmental Programs began participating in the cruise in 1979 to collect adult oysters for heavy metal, PCB, and pesticide analysis. This effort was initiated to create a continuous record of heavy metal, PCB, and pesticide levels in oyster tissue on a broad Bay wide scale.

Study Area Description

The Chesapeake Bay is the largest estuary in the United States. The Bay and its tributaries cover a total area of approximately 4400 square miles of surface water of which 2475 square miles are in Maryland. Within the Maryland portion, the Bay proper covers 1310 square miles, while the remaining area (1165 square miles) consists of tidal tributaries. The Chesapeake Bay is approximately 200 miles in total length; the Maryland portion extends 125 miles southward. There are approximately 3950 square miles of tidal shoreline in the State of Maryland. The average depth of the open Bay is 28 feet and the average depth of the entire system, including tributaries, is 21 feet. The deepest area of the Bay lies in the Maryland portion off Bloody Point at the south end of Kent Island.

That portion of the Chesapeake Bay belonging to Maryland includes the Bay and its tributaries which lie north of Smith Point at the entrance to the Potomac River. All of the Potomac River, except for its southern tributaries and the area within the District of Columbia, is owned by the State of Maryland. The Maryland - Virginia line extends from the mouth of the Potomac River through the middle of Pocomoke Sound on the Eastern Shore.

METHODS AND MATERIALS

Sample Collection

Crassostrea virginica were collected using harvesting gear aboard the University of Maryland's R/V Aquarius from September 24 thru October 5, 1979. Oysters taken from 48 sites were analyzed for heavy metal, PCB and pesticide contamination (Figure 1). All oysters were adult animals of commercial size. Commercial size for oysters in the State of Maryland is $\geq$ 3 inches.

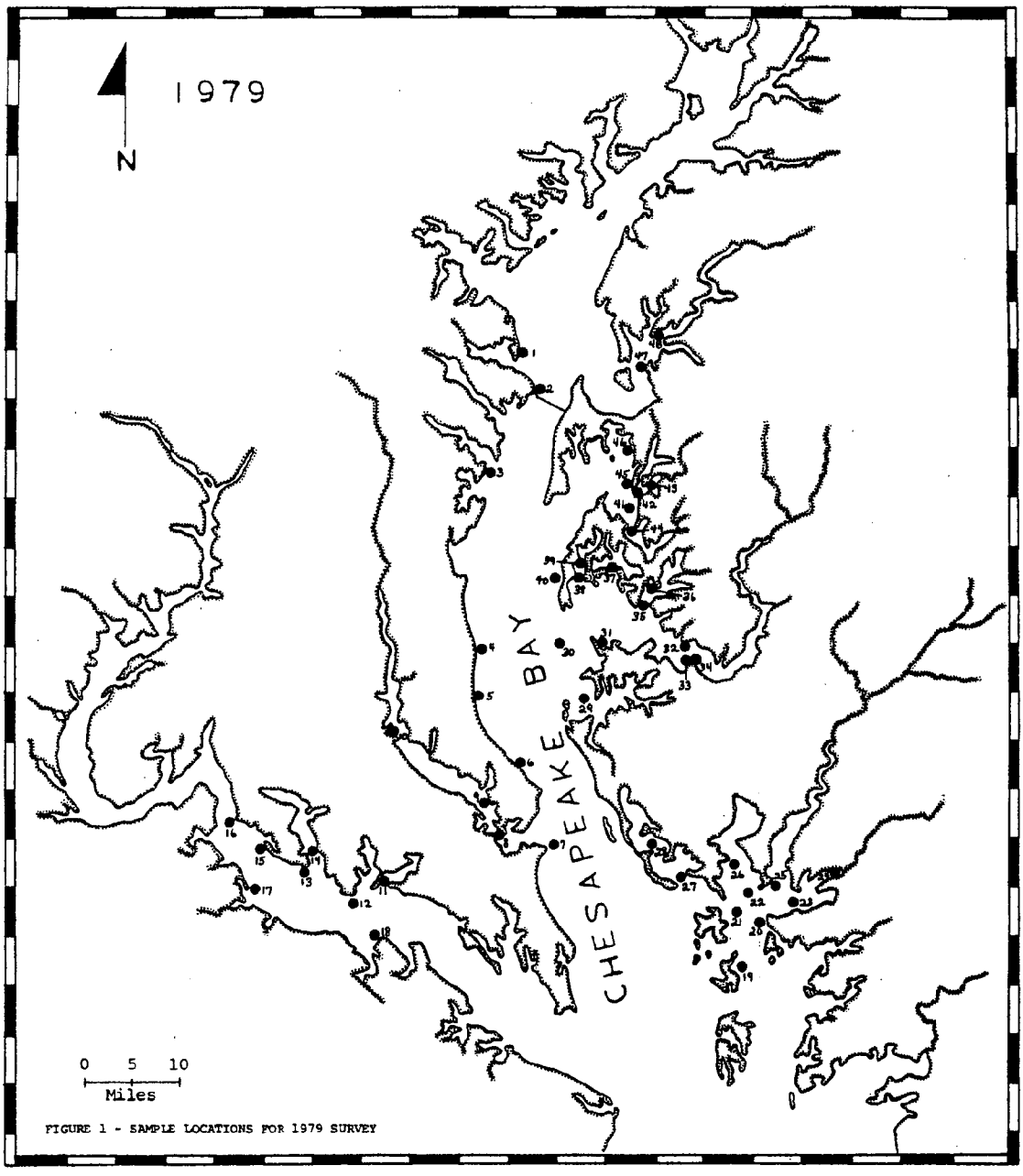

FIGURE 1 - SAMPLE LOCATIONS FOR 1979 SURVEY

Laboratory Analyses

The shellfish were scrubbed clean, shucked and drained and the shells discarded. Each sample was a composite of oyster meats collected from a single location. The number of animals used in each sample was determined by the grams of tissue necessary for the analyses. For pesticide and PCB analyses, approximately 200 grams of shellfish meat were homogenized and a 100 gram portion was analyzed. All PCB and pesticide analyses were in accordance with the Food and Drug Administration's Pesticide Analytical Manual (1977).

For heavy metal analyses, approximately 200 grams of shellfish meat was homogenized. Twenty to thirty grams of the homogenate were used for all heavy metal analyses except mercury and arsenic. Analysis for mercury required 5 - 10 grams of homogenate while arsenic analysis required 30 - 50 grams of homogenate. The shellfish were analyzed for copper, zinc, cadmium, chromium and lead in accordance with Chemical Procedures: NSSP - Collection, Preparation and Analysis of Trace Metals in Shellfish (1975). Arsenic was analyzed in accordance with Official Methods of Analysis of the Association of Official Agricultural Chemists (1975) and mercury was analyzed in accordance with methods presented by Munns and Holland (1977). Laboratory results for heavy metals, PCBs, and pesticides were recorded in parts per million (ppm) wet weight. Results of lead, chromium and arsenic analyses were sometimes recorded as less than (<) detectable limits. Non-detectable levels of PCBs and pesticides were recorded as zero.

Statistical Analyses

Heavy metal, PCB and pesticide ranges, medians, means and standard deviations were determined for the entire Bay and for some major river systems. Sub-basins were further divided and heavy metal, PCB and pesticide means for different areas determined.

Heavy metal, PCB and pesticide levels recorded as less than detectable limits, trace or as non-detectable were considered zero when calculating statistical parameters. Means and standard deviations less than detectable limits were recorded as zero.

RESULTS

Tables 1*a* thru 1*e* present statistical parameters evaluated for the entire Bay and for some major river systems. Figures 2 thru 9 show sub-basins of the Bay and Tables 2 thru 9 present the heavy metal, PCB and pesticide means in the sub-basins.

TABLE 1*a* - 1979 HEAVY METAL, PCB AND PESTICIDE LEVELS IN OYSTERS FROM THE CHESAPEAKE BAY AND ITS TRIBUTARIES

Heavy Metals (n = 48)*	Range (ppm)	Mean (ppm)	Standard Deviation (ppm)	Median (ppm)
Cu	6.39 - 43.9	24.2	9.7	23.0
Zn	248 - 719	486	107	490
Pb	all samples <0.5	0	0	<0.5
Hg	0.002 - 0.015	0.008	0.003	0.008
Cd	0.23 - 1.66	0.73	0.35	0.64
Cr	<0.1 - 0.23	0	0	<0.1
As	<0.05 - 1.27	0.24	0.34	0.06
Polychlorinated Biphenyls (n=48)*	**Range (ppm)**	**Mean (ppm)**	**Standard Deviation (ppm)**	**Median (ppm)**
PCB 1260	ND† - 0.020	0.002	0.005	ND†
PCB 1254	ND† - 0.050	0.010	0.010	0.009
Pesticides (n = 48)*	**Range (ppm)**	**Mean (ppm)**	**Standard Deviation (ppm)**	**Median (ppm)**
Hexachlorobenzene	all samples ND†	0	0	ND†
DDE	ND† - 0.004	0.002	0.001	0.002
αBHC	ND† - trace	0	0	ND†
Lindane	all samples ND†	0	0	ND†
Chlordane	0.002 - 0.020	0.008	0.003	0.008
Heptachlor Epoxide	all samples ND†	0	0	ND†
DDD	ND† - 0.010	0.001	0.002	0.001
DDT	all samples ND†	0	0	ND†
Dacthal	all samples ND†	0	0	ND†
Dieldrin	ND† - 0.007	0.002	0.001	0.002
Endrin	all samples ND†	0	0	ND†
Toxaphene	all samples ND†	0	0	ND†

* sample size

† ND = Not Detectable

NOTE: Heavy metal, PCB and pesticide samples recorded as less than detectable limits, trace or not detectable were considered zero when calculating means and standard deviations.

TABLE 1b - 1979 HEAVY METAL, PCB AND PESTICIDE LEVELS IN OYSTERS - POTOMAC RIVER AND ITS TRIBUTARIES (Sub-Basin 02-14-01)

Heavy Metals (n = 8)*	Range (ppm)	Mean (ppm)	Standard Deviation (ppm)	Median (ppm)
Cu	6.39 - 31.2	14.3	8.2	13.0
Zn	248 - 453	337	68	357
Pb	all samples <0.5	0	0	<0.5
Hg	0.006 - 0.013	0.010	0.002	0.010
Cd	0.23 - 0.55	0.38	0.11	0.37
Cr	<0.1 - 0.14	0	0	<0.1
As	<0.05 - 0.80	0.31	0.34	0.24
Polychlorinated Biphenyls (n = 8)*	**Range (ppm)**	**Mean (ppm)**	**Standard Deviation (ppm)**	**Median (ppm)**
PCB 1260	all samples ND†	0	0	ND†
PCB 1254	0.009 - 0.050	0.024	0.015	0.020
Pesticides (n = 8)*	**Range (ppm)**	**Mean (ppm)**	**Standard Deviation (ppm)**	**Median (ppm)**
Hexachlorobenzene	all samples ND†	0	0	ND†
DDE	trace- 0.004	0.002	0.001	0.002
αBHC	ND† - trace	0	0	ND†
Lindane	all samples ND†	0	0	ND†
Chlordane	0.005 - 0.020	0.011	0.006	0.010
Heptachlor Epoxide	all samples ND†	0	0	ND†
DDD	trace- 0.010	0.003	0.003	0.002
DDT	all samples ND†	0	0	ND†
Dacthal	all samples ND†	0	0	ND†
Dieldrin	ND† - 0.002	0	0.001	trace
Endrin	all samples ND†	0	0	ND†
Toxaphene	all samples ND†	0	0	ND†

* sample size

† ND = Not Detectable

NOTE: Heavy metal, PCB and pesticide samples recorded as less than detectable limits, trace or not detectable were considered zero when calculating means and standard deviations.

TABLE 1c - 1979 HEAVY METAL, PCB AND PESTICIDE LEVELS IN OYSTERS FROM THE PATUXENT RIVER AND ITS TRIBUTARIES (Sub-Basin 02-13-11)

Heavy Metals (n = 3)*	Range (ppm)	Mean (ppm)	Standard Deviation (ppm)	Median (ppm)
Cu	20.9 - 30.7	24.7	5.2	22.5
Zn	402 - 594	469	109	410
Pb	all samples <0.5	0	0	<0.5
Hg	0.005 - 0.010	0.007	0.003	0.006
Cd	1.09 - 1.26	1.18	0.08	1.19
Cr	<0.1 - 0.1	0	0	<0.1
As	0.68 - 1.27	1.03	0.31	1.14
Polychlorinated Biphenyls (n = 3)*	**Range (ppm)**	**Mean (ppm)**	**Standard Deviation (ppm)**	**Median (ppm)**
PCB 1260	0.009 - 0.010	0.010	0	0.010
PCB 1254	all samples ND†	0	0	ND†
Pesticides (n = 3)*	**Range (ppm)**	**Mean (ppm)**	**Standard Deviation (ppm)**	**Median (ppm)**
Hexachlorobenzene	all samples ND†	0	0	ND†
DDE	0.002 - 0.004	0.003	0.001	0.003
αBHC	ND† - trace	0	0	ND†
Lindane	all samples ND†	0	0	ND†
Chlordane	all samples 0.005	0.005	0	0.005
Heptachlor Epoxide	all samples ND†	0	0	ND†
DDD	trace - 0.002	0.001	0.001	0.001
DDT	all samples ND†	0	0	ND†
Dacthal	all samples ND†	0	0	ND†
Dieldrin	0.001 - 0.002	0.001	0.001	0.001
Endrin	all samples ND†	0	0	ND†
Toxaphene	all samples ND†	0	0	ND†

* sample size
† ND = Not Detectable

NOTE: Heavy metal, PCB and pesticide samples recorded as less than detectable limits, trace or not detectable were considered zero when calculating means and standard deviations.

TABLE 1*d* - 1979 HEAVY METAL, PCB AND PESTICIDE LEVELS IN OYSTERS - CHOPTANK RIVER AND ITS TRIBUTARIES (Sub Basin 02-13-04)

Heavy Metals (n = 9)*	Range (ppm)	Mean (ppm)	Standard Deviation (ppm)	Median (ppm)
Cu	23.9 - 43.9	35.2	6.3	33.9
Zn	497 - 639	562	45	557
Pb	all samples <0.5	0	0	<0.5
Hg	0.007 - 0.015	0.011	0.003	0.011
Cd	0.76 - 1.34	1.01	0.18	1.00
Cr	<0.1 - 0.23	0.13	0.10	0.16
As	<0.05 - 1.04	0.22	0.33	0.10

Polychlorinated Biphenyls (n = 9)*	Range (ppm)	Mean (ppm)	Standard Deviation (ppm)	Median (ppm)
PCB 1260	ND† - 0.020	0.002	0.007	ND†
PCB 1254	ND† - 0.020	0.009	0.005	0.008

Pesticides (n = 9)*	Range (ppm)	Mean (ppm)	Standard Deviation (ppm)	Median (ppm)
Hexachlorobenzene	all samples ND†	0	0	ND†
DDE	0.001 - 0.003	0.002	0.001	0.002
αBHC	all samples ND†	0	0	ND†
Lindane	all samples ND†	0	0	ND†
Chlordane	0.007 - 0.010	0.009	0.001	0.010
Heptachlor Epoxide	all samples ND†	0	0	ND†
DDD	trace - 0.002	0.001	0.001	0.001
DDT	all samples ND†	0	0	ND†
Dacthal	all samples ND†	0	0	ND†
Dieldrin	0.002 - 0.003	0.003	0	0.003
Endrin	all samples ND†	0	0	ND†
Toxaphene	all samples ND†	0	0	ND†

* sample size

† ND = Not Detectable

NOTE: Heavy metal, PCB and pesticide samples recorded as less than detectable limits, trace or not detectable were considered zero when calculating means and standard deviations.

TABLE 1e - 1979 HEAVY METAL, PCB AND PESTICIDE LEVELS IN OYSTERS
- UPPER TANGIER SOUND AND ITS TRIBUTARIES
(Sub Basins 02-13-03 and 02-13-02)

Heavy Metals (n = 8)*	Range (ppm)	Mean (ppm)	Standard Deviation (ppm)	Median (ppm)
Cu	12.5 - 32.6	26.0	6.7	27.4
Zn	347 - 715	541	107	548
Pb	all samples <0.5	0	0	<0.5
Hg	0.002 - 0.014	0.007	0.003	0.007
Cd	0.30 - 0.65	0.48	0.11	0.46
Cr	<0.1 - 0.17	0	0	<0.1
As	<0.05 - 0.14	0	0.05	<0.05

Polychlorinated Biphenyls (n = 8)*	Range (ppm)	Mean (ppm)	Standard Deviation (ppm)	Median (ppm)
PCB 1260	ND† - 0.010	0.006	0.004	0.006
PCB 1254	ND† - 0.004	0.001	0.002	ND†

Pesticides (n = 8)*	Range (ppm)	Mean (ppm)	Standard Deviation (ppm)	Median (ppm)
Hexachlorobenzene	all samples ND†	0	0	ND†
DDE	ND† - 0.001	0.001	0	0.001
αBHC	ND† - trace	0	0	ND†
Lindane	all samples ND†	0	0	ND†
Chlordane	0.002 - 0.005	0.004	0.001	0.004
Heptachlor Epoxide	all samples ND†	0	0	ND†
DDD	ND† - 0.001	0	0	trace
DDT	all samples ND†	0	0	ND†
Dacthal	all samples ND†	0	0	ND†
Dieldrin	ND† - 0.001	0	0	ND†/trace
Endrin	all samples ND†	0	0	ND†
Toxaphene	all samples ND†	0	0	ND†

* sample size

† ND = Not Detectable
NOTE: Heavy metal, PCB and pesticide samples recorded as less than detectable limits, trace or not detectable were considered zero when calculating means and standard deviations.

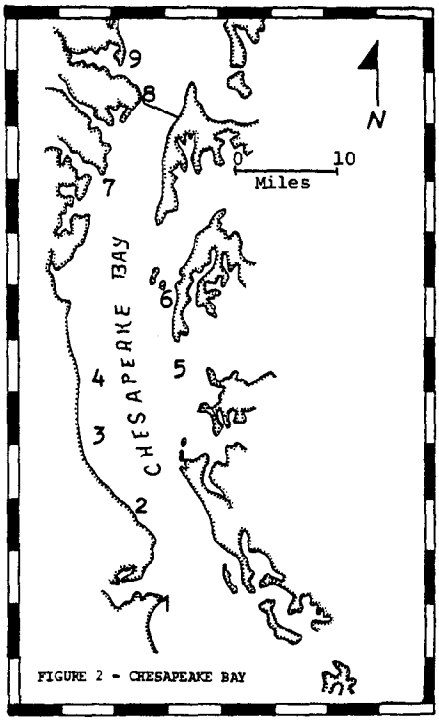

FIGURE 2 - CHESAPEAKE BAY

TABLE 2 - HEAVY METAL, PCB AND PESTICIDE LEVELS (expressed in ppm) IN OYSTERS SAMPLED FROM THE MAINSTEM OF THE CHESAPEAKE BAY IN 1979

Location *	Cu	Zn	Hg	Cd	Cr	As
1 (1)	10.9	398	0.006	0.28	0	0.80
2 (1)	25.5	616	0.006	0.97	0	0.08
3 (1)	14.8	536	0.006	0.57	0	0.58
4 (1)	16.9	508	0.008	0.84	0	0.42
5 (1)	24.1	527	0.007	0.88	0.12	0
6 (1)	15.6	416	0.006	0.43	0.15	0
7 (1)	29.2	541	0.006	0.82	0	0.47
8 (1)	41.1	719	0.007	1.49	0.13	0
9 (1)	42.9	611	0.006	1.66	0.12	0.56

Location *	DDE	PCB 1260	PCB 1254	Chlordane	DDD	Dieldrin
1 (1)	0.001	0	0.010	0.007	trace	0.001
2 (1)	0.001	0	0.010	0.010	0.001	0.002
3 (1)	0.001	0	0.008	0.006	trace	0.001
4 (1)	0.002	0	0.010	0.008	0.001	0.001
5 (1)	0.001	0.010	0	0.009	0.002	0.002
6 (1)	0.002	0	0.020	0.009	0.002	0.007
7 (1)	0.001	0	0.010	0.008	0	0
8 (1)	0.002	0	0.020	0.008	0.003	0.001
9 (1)	0.002	0	0.020	0.010	0.003	0.002

* Sample size in parentheses

NOTE: Heavy metal, PCB and pesticide samples recorded as less than detectable limits, trace or not detectable were considered zero when calculating means.

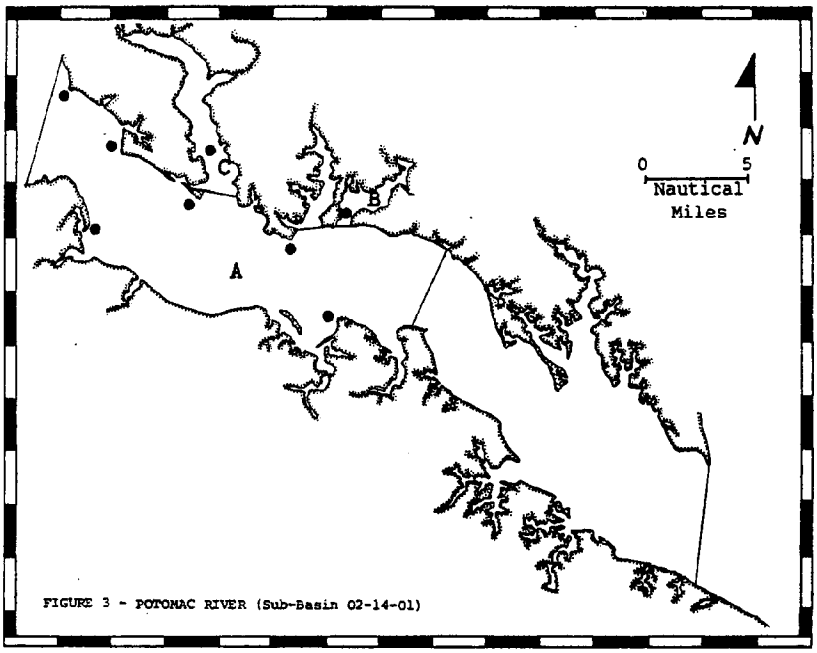

FIGURE 3 - POTOMAC RIVER (Sub-Basin 02-14-01)

TABLE 3 - HEAVY METAL, PCB AND PESTICIDE MEANS (expressed in ppm) FOR OYSTERS SAMPLED FROM DIFFERENT AREAS OF THE POTOMAC RIVER IN 1979

Location *	Cu	Zn	Hg	Cd	Cr	As
A - Middle Potomac River (6)	15.7	347	0.010	0.37	0	0.41
B - Breton Bay (1)	6.96	248	0.009	0.27	0	0
C - Wicomico River (1)	13.3	363	0.010	0.52	0	0

Location *	DDE	PCB1260	PCB1254	Chlordane	DDD	Dieldrin
A (6)	0.002	0	0.022	0.013	0.004	0
B (1)	0	0	0.050	0.005	0	0
C (1)	0.002	0	0.010	0.010	0.002	0.001

* Sample size in parentheses

NOTE: Heavy metal, PCB and pesticide samples recorded as less than detectable limits, trace or not detectable were considered zero when calculating means.

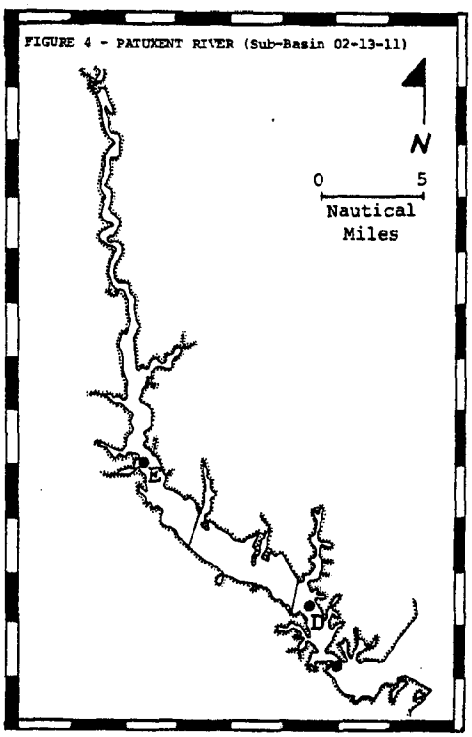

TABLE 4 - HEAVY METAL, PCB AND PESTICIDE MEANS (expressed in ppm) FOR OYSTERS SAMPLED FROM DIFFERENT AREAS OF THE PATUXENT RIVER IN 1979

Location *	Cu	Zn	Hg	Cd	Cr	As
D - Lower Patuxent River (2)	25.8	498	0.008	1.14	0	1.20
E - Upper Patuxent River (1)	22.5	410	0.006	1.26	0	.68

Location *	DDE	PCB1260	PCB1254	Chlordane	DDD	Dieldrin
D (2)	0.004	0.010	0	0.005	0.001	0.002
E (1)	0.002	0.010	0	0.005	0.002	0.001

* Sample size in parentheses

NOTE: Heavy metal, PCB and pesticide samples recorded as less than detectable limits, trace or not detectable were considered zero when calculating means.

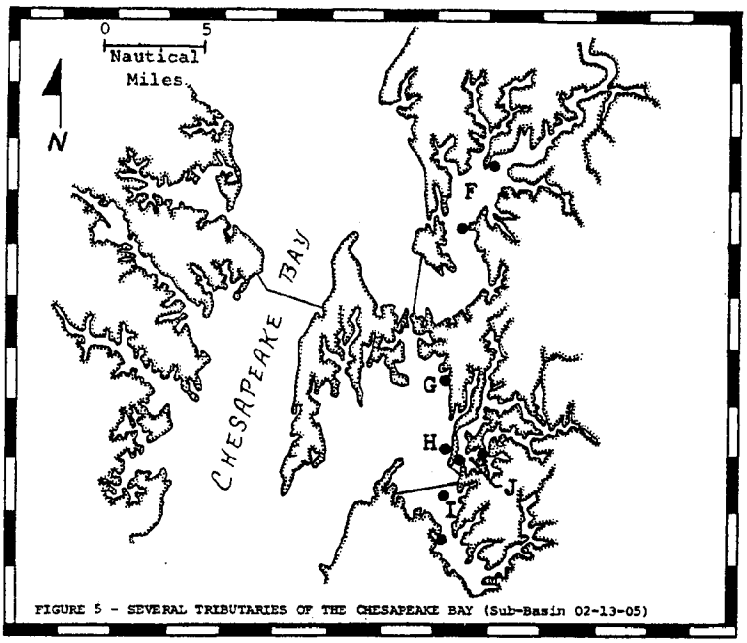

FIGURE 5 - SEVERAL TRIBUTARIES OF THE CHESAPEAKE BAY (Sub-Basin 02-13-05)

TABLE 5 - HEAVY METAL, PCB AND PESTICIDE MEANS (expressed in ppm) FOR OYSTERS SAMPLED FROM SEVERAL RIVERS IN 1979

Location *		Cu	Zn	Hg	Cd	Cr	As
F - Chester River	(2)	24.7	467	0.006	1.04	0.18	0.08
G - North Eastern Bay	(1)	26.4	455	0.007	0.44	0	0
H - South Eastern Bay	(1)	16.6	421	0.008	0.58	0	0.59
I - Miles River	(2)	23.4	464	0.010	0.65	0.14	0
J - Wye River	(2)	22.1	440	0.010	0.82	0.16	0.06

Location *		DDE	PCB1260	PCB1254	Chlordane	DDD	Dieldrin
F	(2)	0.002	0	0.009	0.008	0.002	0.002
G	(1)	0.001	0	0.009	0.005	0	0
H	(1)	0.002	0	0.010	0.009	0.009	0.002
I	(2)	0.001	0	0.008	0.006	0	0.002
J	(2)	0.002	0	0.010	0.006	0	0.003

* Sample size in parentheses

Note: Heavy metal, PCB and pesticide samples recorded as less than detectable limits, trace or not detectable were considered zero when calculating means.

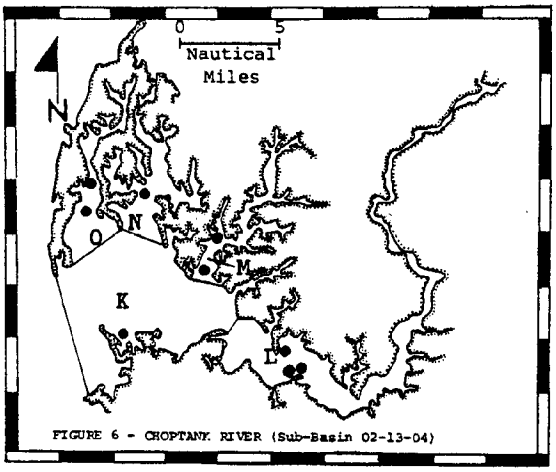

FIGURE 6 - CHOPTANK RIVER (Sub-Basin 02-13-04)

TABLE 6 - HEAVY METAL, PCB AND PESTICIDE MEANS (expressed in ppm) IN OYSTERS SAMPLED FROM DIFFERENT AREAS OF THE CHOPTANK RIVER IN 1979

Location *		Cu	Zn	Hg	Cd	Cr	As
K - Lower Choptank River	(1)	23.9	497	0.007	0.76	0.13	0.13
L - Middle Choptank River	(3)	34.2	558	0.010	0.97	0.11	0.42
M - Tred Avon River	(2)	33.8	611	0.012	0.96	0.16	0.05
N - Broad Creek	(1)	43.9	557	0.015	1.16	0	0
O - Harris Creek	(2)	39.3	555	0.011	1.17	0.20	0.24

Location *		DDE	PCB1260	PCB1254	Chlordane	DDD	Dieldrin
K	(1)	0.002	0	0.010	0.008	0.001	0.002
L	(3)	0.002	0.007	0.007	0.010	0.001	0.003
M	(2)	0.002	0	0.014	0.008	0.001	0.002
N	(1)	0.001	0	0.008	0.010	0	0.003
O	(2)	0.002	0	0.008	0.009	0.001	0.002

* Sample size in parentheses

Note: Heavy metal, PCB and pesticide samples recorded as less than detectable limits, trace or not detectable were considered zero when calculating means.

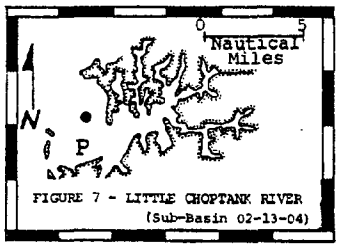

FIGURE 7 - LITTLE CHOPTANK RIVER
(Sub-Basin 02-13-04)

TABLE 7 - HEAVY METAL PCB AND PESTICIDE MEANS (expressed in ppm) IN OYSTERS SAMPLED FROM THE LITTLE CHOPTANK RIVER IN 1979

Location *		Cu	Zn	Hg	Cd	Cr	As
P	(1)	17.9	447	0.006	0.46	0	0.08

		DDE	PCB1260	PCB1254	Chlordane	DDD	Dieldrin
P	(1)	0.002	0	0.009	0.007	0.001	0.003

* Sample size in parentheses

Note: Heavy metal, PCB and pesticide samples recorded as less than detectable limits, trace or not detectable were considered zero when calculating means.

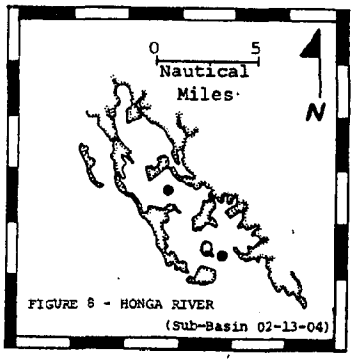

FIGURE 8 - HONGA RIVER
(Sub-Basin 02-13-04)

TABLE 8 - HEAVY METAL, PCB AND PESTICIDE MEANS (expressed in ppm) IN OYSTERS SAMPLED FROM THE HONGA RIVER IN 1979

Location *		Cu	Zn	Hg	Cd	Cr	As
Q	(2)	13.7	462	0.008	0.54	0	0

		DDE	PCB1260	PCB1254	Chlordane	DDD	Dieldrin
Q	(2)	0.002	0.010	0	0.006	0.002	0.001

* Sample size in parentheses

Note: Heavy metal, PCB and pesticide samples recorded as less than detectable limits, trace or not detectable were considered zero when calculating means.

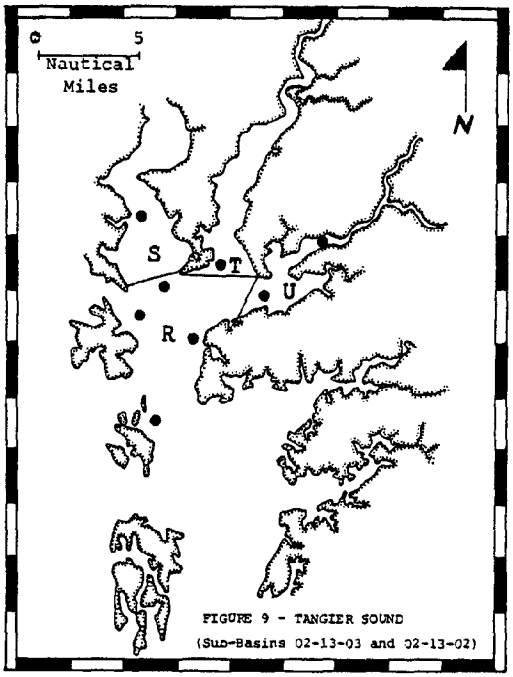

FIGURE 9 - TANGIER SOUND
(Sub-Basins 02-13-03 and 02-13-02)

TABLE 9 - HEAVY METAL, PCB AND PESTICIDE MEANS (expressed in ppm) IN OYSTERS SAMPLED FROM THE TANGIER SOUND AREA IN 1979

Location *		Cu	Zn	Hg	Cd	Cr	As
R - Upper Tangier Sound	(4)	23.9	532	0.009	0.50	0	0
S - Fishing Bay	(1)	32.6	619	0.007	0.54	0	0
T - Nanticoke River	(1)	30.6	538	0.008	0.40	0	0
U - Wicomico River	(2)	24.6	522	0.004	0.46	0	0

Location *		DDE	PCB1260	PCB1254	Chlordane	DDD	Daildrin
R	(4)	0	0.006	0	0.004	0	0
S	(1)	0.001	0.010	0	0.005	0.001	0
T	(1)	0.001	0.008	0	0.004	0	0
U	(2)	0.001	0	0.004	0.004	0	0

*Sample size in parentheses

NOTE: Heavy metal, PCB and pesticide samples recorded as less than detectable limits, trace or not detectable were considered zero when calculating means.

DISCUSSION

Several trends were suggested by the 1979 data when evaluated by major river systems. Mean levels of both copper and zinc in oyster tissues exhibited the following trend: Choptank River > Upper Tangier Sound > Patuxent River > Potomac River. Mercury means were approximately equal in all four areas. Mean levels of cadmium in oyster tissues exhibited the following trend: Patuxent River > Choptank River > Upper Tangier Sound > Potomac River. Chromium was more prevalent in oyster tissues from the Choptank River ($\bar{x}$ = 0.13 ppm) than in oysters from the Patuxent River, Potomac River and Upper Tangier Sound ($\bar{x}$ = 0 ppm). Mean levels of arsenic exhibited the following trend: Patuxent River > Potomac River > Choptank River > Upper Tangier Sound.

It is difficult to determine what may contribute to the heavy metal differences between river systems and the significance of these levels. The trends may indicate natural differences between areas or possible sources associated with human habitation.

Analyses of the 1979 data by station location within the river systems indicated a definite trend. Mean levels of copper, zinc and cadmium in oyster tissues were greater upstream than downstream in the Chesapeake Bay mainstem, Choptank River and Upper Tangier Sound. Some of these areas are not located near point source discharges suggesting that other factors affect the system.

Huggett *et al.* (1975), investigating salinity effects on the uptake of copper and zinc by oysters in rivers in North Carolina and Virginia noted a concentration gradient. Oysters living in fresher waters had higher concentrations of metals than those in more saline waters. Theories involving concentration gradients of copper and zinc dissolved in water or as particulates in sediment were not supported by the data. Huggett *et al.* (1975) suggested the following possible alternate explanations.

1. Oysters may take up metals from the environment with calcium by a nonspecific ion-transport mechanism in order to satisfy the high calcium requirements for shell deposition. In low salinity waters, where calcium levels would be lower, the animals may have to extract calcium more efficiently and greater quantities of other cations may be taken up as a result.

2. In high salinity waters, cations that are at higher concentrations than copper and zinc may take away binding sites.

3. Chelation of metals in solution by natural organics like fulvic acids would make elements more available to the oyster. Assuming that humic substances are from decaying plant materials, the concentrations of fulvic acids would decrease with increasing salinity because of dilution.

Mercury means from different areas within rivers in 1979 were similar. Chromium and arsenic means on the other hand, exhibited greater differences between areas but no consistent trend were evident.

In the Chesapeake Bay mainstem data analyses, location 2 had higher levels of copper, zinc, and cadmium than might have been expected when compared to other mainstem samples. The Calvert Cliffs Nuclear Power Plant, located nearby, may have had some influence. Mercury, chromium and arsenic levels in oyster tissues did not appear to be affected.

Evaluation of the 1979 data according to major river systems indicated that DDE, PCB 1260, PCB 1254, chlordane, DDD and dieldrin were the only pesticides recurring regularly in oyster tissues. DDE, DDD, and dieldrin means did not exhibit much variation between rivers while PCB 1260, PCB 1254 and chlordane did. PCB 1254 levels in Chesapeake Bay shellfish reported by Eisenberg *et al.* (1980) were in general agreement with levels found during the 1979 Oyster Spat Survey.

Since PCBs and pesticides are synthetic substances their presence indicates man's impact on the environment. In the case of pesticides, the most likely source in the environment results from agricultural useage. Pesticide differences between rivers may be indicative of land use patterns.

Copper, cadmium, PCB 1254, dieldrin and DDE levels in oysters reported by Garreis and Pittman (1981) in a study of heavy metal, PCB and pesticide levels in Choptank River oysters and soft shell clams were consistent with Choptank River levels reported here. Levels of zinc, mercury, PCB 1260, chlordane and DDD in oysters were greater in the Choptank River report. The Choptank River report did not incorporate samples taken from tributaries whereas the spat survey evaluation included samples from the Tred Avon, Harris and Broad Creeks in determining overall means.

Since the Office of Environmental Programs has only recently initiated this survey of heavy metal and pesticide levels in conjunction with the Oyster Spat Survey there is inconclusive evidence at present to determine whether any of the apparent differences between rivers are significant. As this program continues and the data base expanded it is expected that the significance of some of these trends may be determined.

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