U. S. GEOLOGICAL SURVEY

WATER-QUALITY ASSESSMENT OF THE ALBEMARLE-PAMLICO DRAINAGE BASIN, NORTH CAROLINA AND VIRGINIA— Trace elements in Asiatic clam (*Corbicula fluminea*) soft tissues and redbreast sunfish (*Lepomis auritus*) livers, 1992-93

BY PETER M. RUHL AND KELLY E. SMITH

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INTRODUCTION

The analysis of potential contaminants in biological tissues is an important part of many water-quality assessment programs, including the U.S. Geological Survey's National Water Quality Assessment (NAWQA) Program. Tissue analyses often are used to provide information about (1) direct threats to human health and ecosystem integrity, and (2) the occurrence and distribution of potential contaminants in the environment. The use of tissue analyses in the NAWQA Program concentrates on the second objective of providing information about the occurrence and distribution of potential contaminants in the Nation's surface-water resources.

In their guidelines for NAWQA tissue sampling, Crawford and Luoma (1993) recognize four important attributes of tissue analysis. First, tissue analysis can increase the likelihood of detecting small amounts of contaminants because contaminant concentrations can be higher in tissues than in water. Second, tissues can "store" time-averaged measurements or records of the presence of contaminants in the environment. Third, tissue analysis is a direct measurement of the contaminants that accumulate in biological organisms; and finally, integrating tissue analysis with water and sediment analysis produces complementary information about contaminant fate, distribution, and effects.

During 1992-93, trace elements in Asiatic clam (*Corbicula fluminea*) soft tissues and redbreast sunfish (*Lepomis auritus*) livers were analyzed to obtain information about the occurrence and distribution of trace element contaminants in the Albemarle-Pamlico Drainage Basin of North Carolina and Virginia (fig. 1). This investigation was conducted as part of the NAWQA Program. This report briefly summarizes the results of this investigation.

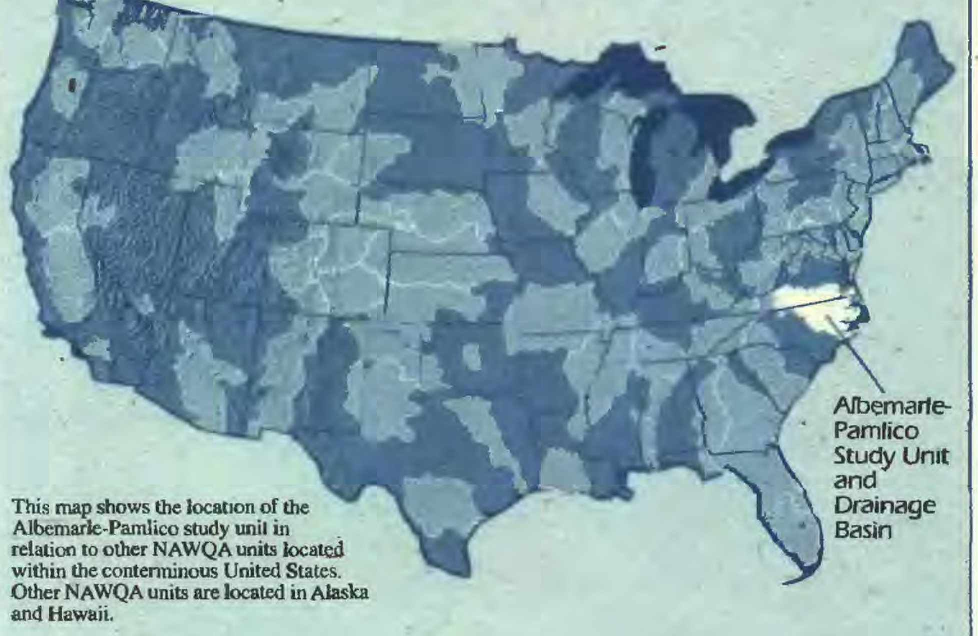
SUMMARY OF RESULTS

- 19 of 22 trace elements were detected.
- Although all 10 of the U.S. Environmental Protection Agency (U.S. EPA) priority pollutants were detected in the tissues sampled, they were present in relatively low concentrations.
- Concentrations of U.S. EPA priority pollutants in Asiatic clams collected in the Albemarle-Pamlico Drainage Basin are similar to concentrations observed in other NAWQA study units in the southeastern United States.
- Mercury (a U.S. EPA priority pollutant) was widely detected, being present in 29 of 30 tissue samples, but concentrations did not exceed the FDA action level for mercury or a risk-based screening value for the general public. Mercury concentrations in Asiatic clams were similar to concentrations in other NAWQA study areas in the Southeast.

NATIONAL WATER-QUALITY ASSESSMENT (NAWQA) PROGRAM

The U. S. Geological Survey's NAWQA Program is designed to assess historical, current, and future water-quality conditions in a large, representative part of the Nation's surface- and ground-water resources, and to examine the natural and human factors that affect the quality of these water resources (Leahy and others, 1990). Understanding the major factors that affect water quality at local, regional, and national levels can provide a scientific basis for water-management decisions.

NATIONAL NAWQA STUDY UNITS WITHIN THE CONTERMINOUS UNITED STATES



This map shows the location of the Albemarle-Pamlico study unit in relation to other NAWQA units located within the conterminous United States. Other NAWQA units are located in Alaska and Hawaii.

BASIN DESCRIPTION

The Albemarle-Pamlico Drainage Basin is one of 60 NAWQA study units nationwide. The study area encompasses about 28,000 square miles (mi^2) in central and eastern North Carolina and southern Virginia and includes four major river basins–the Chowan, Roanoke, Tar, and Neuse. The Albemarle-Pamlico Drainage Basin extends through parts of four physiographic provinces–Valley and Ridge, Blue Ridge, Piedmont, and Coastal Plain. About 50 percent of the land in the basin is forested; 30 percent is cropland; 15 percent is wetland, and 5 percent is developed (Woodside and Simerl, 1996). The barrier islands, estuaries, and associated sounds in the drainage basin are not included in the NAWQA study area.

SELECTION OF TAXA FOR ANALYSIS

The emphasis of the NAWQA Program on providing information about the occurrence and distribution of potential contaminants influences the selection of targeted species and sampling methods. NAWQA guidelines for studies of contaminants in tissues promote national consistency by recommending the analysis of a specific suite of organisms and tissues. This suite of organisms and tissues is designated by NAWQA's National Target Taxa (NATT) list (Crawford and Luoma, 1993). This list and the guidelines for applying it provided the basis for targeting Asiatic clam soft tissues and redbreast sunfish livers for the Albemarle-Pamlico NAWQA study.

The NATT list places highest priority on the selection of Asiatic clams for analysis because they are widely distributed nationally, remain in one location, and accumulate both trace elements and organic contaminants (Crawford and Luoma, 1993). If Asiatic clams cannot be found at a site, the NATT list recommends targeting appropriate aquatic insects or the livers of bottom-feeding fishes. For the Albemarle-Pamlico NAWQA study, redbreast sunfish were targeted if Asiatic clams could not be found because redbreast sunfish were the only fish species that could be consistently captured at a majority of the sites. Redbreast sunfish are generalist predators which eat insects, molluscs, arthropods, and even fish (Jenkins and Burkhead, 1993). Sites where neither Asiatic clams nor redbreast sunfish could be found were eliminated from the study.

SAMPLING SITES

During 1992-93, a total of 30 tissue samples were collected from 19 sites in the Albemarle-Pamlico NAWQA study area (fig. 1; table 1). The sites were selected to (1) include as many of the NAWQA fixed water-quality monitoring sites in the study area as possible, (2) target land uses, and (3) improve spatial distribution. Of the 12 NAWQA fixed water-quality sites, 9 were sampled. Fixed sites are locations where physical, chemical and biological data are collected and assessed. The fixed sites are selected to represent a range of spatial and temporal scales and environmental settings in the study area and are of two types–integrator and indicator. Integrator sites are established at downstream points in large drainage basins that collect water from hundreds or thousands of square miles. These sites reflect water-quality effects from many different kinds of land uses. Indicator sites are located in relatively small drainage basins (generally less than 100 mi²) that are typically dominated by one or two land uses. These sites are selected to represent specific land uses that could be related to water-quality characteristics (Spruill and others, 1995). For the analysis of trace elements in tissues, the majority of the sampling effort was concentrated in integrator and indicator sites in the Coastal Plain (fig. 1; table 1).

In 1992, Asiatic clams were collected at 15 sites (table 1). Seven of these sites are integrator sites located in the Coastal Plain. Asiatic clams also were collected at two integrator sites in the Piedmont–Tar River near Tar River (fig.1, site 8) and Swift Creek near Hilliardston (fig. 1, site 9). The remaining six Asiatic clam samples were collected from indicator sites–four in the Piedmont and two in the Coastal Plain. Of the sites sampled in the Piedmont, two are located in urban settings.

In 1993, redbreast sunfish were collected at nine sites. Excluding Devils Cradle Creek (fig. 1, site-7), a small Piedmont stream, all redbreast sunfish were collected from sites in the Coastal Plain. Five of the nine sites sampled for redbreast sunfish are mixed-landuse integrator sites. The remaining four sites are fixed indicator sites where land use is primarily agricultural. Of the nine sites sampled in 1993, five were sites where Asiatic clams had been collected the previous year (table 1).

STANDARDS AND GUIDELINES

For some of the trace elements that were analyzed, institutions such as Federal and State agencies have determined standards and guidelines which indicate concentrations in tissues that may have toxic effects on human health, aquatic organisms, or both. These standards and guidelines are commonly applied by comparing them to measured concentrations of individual compounds.

Data collected for this study cannot be used to directly assess potential hazards to human health. This is because standards and guidelines for assessing hazards to human health apply to edible tissues, but the data collected for this study are for inedible tissues. Asiatic clams are not considered edible by humans; and although redbreast sunfish are a popular gamefish, the portion analyzed (liver) does not represent the edible portion (fillet). This means that Food and Drug Administration (FDA) action levels, and U.S. EPA risk-based screening values are not directly applicable.

However, comparing the results of this study to FDA action levels, U.S. EPA risk-based screening values, and other benchmark concentrations can still be helpful because such comparisons can put the results into a broader context. Comparison values used for this study include (1) the FDA action level for mercury, (2) risk-based screening values for the general public calculated by Cunningham and others (1992) for the Albemarle-Pamlico Estuarine Study (APES), (3) the 85th percentiles for whole-fish data collected in 1984 for the U.S. Fish and Wildlife Service's National Contaminant Biomonitoring Program (NCBP), and (4) tissue data collected in other NAWQA study areas in the southeastern United States.

FDA action levels are intended to protect consumers from contaminated food shipped across State lines. If an action level is exceeded, the FDA can take legal action to remove the contaminated food from interstate commerce (Nowell and Resek, 1994).

A risk-based screening value is a concentration calculated using a set of assumptions about the toxicity of a trace element and the amount of fish or shellfish eaten by a particular group of people. The method is based on the idea that if concentrations in tissues are less than the screening value, the group is not being exposed to hazardous concentrations. The assumptions that are used influence the magnitude of the screening value. For example, screening values will be larger for the general population than for subsistence fishermen because members of the general public tend to eat fewer fish less often (Cunningham and others, 1992).

The NCBP 85th percentile for whole fish is the concentration in tissues that is greater than or equal to the concentration in 85 percent of the whole-fish samples collected in 1984 for the NCBP. During 1984 the NCBP collected 321 samples from 112 sites on rivers and streams across the United States (Schmitt and Brumbaugh, 1990). The NCBP 85th percentile also was used for the APES study to identify sites where additional sampling might be needed (Cunningham and others, 1992).

Because the NAWQA program selectively targets Asiatic clams for tissue analyses, data also are available for Asiatic clams collected in three other NAWQA study basins in the southeastern United States. Those data also were compared to the data collected for this study.

Organisms Collected For This Study

Lepomis auritus (redbreast sunfish)

The redbreast sunfish is a native North American freshwater fish. It is found throughout the Atlantic slope from New Brunswick to central Florida and is a popular gamefish in many waters of North Carolina and Virginia. Total length of an adult redbreast sunfish ranges from 90 to 185 millimeters (3 1/2 to 7 1/3 inches) (Jenkins and Burkhead, 1993).

Corbicula fluminea (freshwater Asiatic clam)

The Asiatic clam was introduced to the west coast of the United States in the late 1930's. Presently this freshwater clam can be found across the country due to rapid reproduction and dispersion (Laurisen and Mozley, 1983). Adult clam sizes range from 10 to 50 millimeters long (1/3 to 2 inches) (Pennak, 1989).

Sample Collection and Analysis

Samples were collected and field processed in accordance with national NAWQA guidelines for tissue sampling and analysis (Crawford and Luoma, 1993). Asiatic clams were collected from the streambed with modified rakes. Similar sized clams were selected, where possible, for composite samples of 20 to 70 specimens, depending on the size of the clams. Combining, or compositing, individual specimens provides sufficient mass for analysis and dampens variability caused by unusual concentrations within individual clams. Individual specimens were rinsed with ambient streamwater to remove any attached algae or debris, measured, and placed in an acid-rinsed plastic container filled with ambient water. The container was then placed in a cooler over ice for a minimum of 24 hours to allow the clams to depurate. Depuration is purification by the excretion of waste material, and the procedure is an attempt to eliminate material from the gastrointestinal tract of the clams. Midway through the depuration period, the water was replaced. For shipment, each composite sample was wrapped in plastic, placed in a plastic bag on dry ice, and shipped frozen to the U.S. Geological Survey's (USGS) National Water-Quality Laboratory (NWQL) for further processing and analysis (G.L. Hoffman, U.S. Geological Survey, written commun., 1993). At the NWQL the samples were analyzed for 22 trace elements (table 2).

Redbreast sunfish were collected by electroshocking and then sacrificed in the field by a sharp blow to the base of the head. Each fish was examined for external anomalies, weighed, and measured for total and standard length. Similar to the Asiatic clam samples, redbreast sunfish of approximately the same size were selected for composite samples of 5 to 10 specimens. For shipment, individual fish were placed in plastic bags, labeled appropriately, and then frozen on dry ice. In the USGS North Carolina District laboratory, each fish was partially thawed and the liver was dissected using Teflon-coated and plastic implements. Composite liver samples were placed in acid-rinsed jars, weighed, and shipped to the NWQL for further analyses.

To prevent contamination, all implements used in field processing were carefully washed with phosphate-free detergent and rinsed with 5 percent nitric acid followed by doubly-distilled water. Plastic wrap was used to cover all surfaces that came into contact with the specimens.

Sampling Stations (Figure 1.)

STUDY AREA

TABLE 1. STATIONS IN THE ALBEMARLE-PAMLICO BASIN WHERE ASIATIC CLAMS AND REDBREAST SUNFISH WERE COLLECTED FOR TRACE ELEMENT ANALYSES, 1992-93

Map number (figure 1)	Station name and number (Indicator sites in black, Integrator sites in blue)	Species collected	Drainage area (in square miles)	Physiographic province	Land-use type
1	North Meherrin River near Lunenburg, Va. (02051000)	Asiatic clam	56	Piedmont	Forest/Agriculture
2	[1] Nottoway River near Sebrell, Va. (02047000)	Sunfish and clam	1,433	Coastal Plain	Forest/Agriculture
3	[1] Blackwater River near Franklin, Va. (02049500)	Sunfish and clam	602	Coastal Plain	Forest/Agriculture
4	Roanoke River at Roanoke Rapids, N.C. (02080500)	Asiatic clam	8,434	Coastal Plain	Forest/Agriculture
5	North Flat River at Timberlake, N.C. (02085390)	Asiatic clam	33	Piedmont	Agriculture
6	Ahoskie Creek near Poor Town, N.C. (02053490)	Asiatic clam	54	Coastal Plain	Forest/Agriculture
7	[1] Devils Cradle Creek near Alert, N.C. (02082731)	Redbreast sunfish	13	Piedmont	Agriculture
8	Tar River near Tar River, N.C. (02081500)	Asiatic clam	165	Piedmont	Agriculture/Forest
9	Swift Creek at Hilliardston, N.C. (02082770)	Asiatic clam	172	Piedmont	Agriculture/Forest
10	[1] Tar River at Tarboro, N.C. (02083500)	Sunfish and clam	2,220	Coastal Plain	Forest/Agriculture
11	Crabtree Creek at US 1 at Raleigh, N.C. (02087324)	Asiatic clam	122	Piedmont	Urban
12	[1] Pete Mitchell Swamp near Penny Hill at SR 1409, N.C. (02083833)	Redbreast sunfish	17	Coastal Plain	Agriculture
13	Swift Creek near Apex, N.C. (02087580)	Asiatic clam	20	Piedmont	Urban
14	[1] Chicod Creek at SR 1760 near Simpson, N.C. (02084160)	Sunfish and clam	42	Coastal Plain	Agriculture
15	[1] Contentnea Creek at Hookerton, N.C. (02091500)	Redbreast sunfish	737	Coastal Plain	Agriculture
16	Neuse River near Cox Mill, N.C. (02089500)	Asiatic clam	1,675	Coastal Plain	Forest/Agriculture
17	[1] Bear Creek at Mays Store, N.C. (0208925200)	Redbreast sunfish	59	Coastal Plain	Agriculture
18	[1] Neuse River at Kinston, N.C. (02089500)	Sunfish and clam	2,700	Coastal Plain	Forest/Agriculture
19	Trent River near Trenton, N.C. (02092500)	Asiatic clam	172	Coastal Plain	Forest/Agriculture

[1] Indicates a NAWQA fixed station.

Land-use type explanation:

TRACE ELEMENTS DETECTED

Of the 22 trace elements analyzed, 19 were present in concentrations above the analytical detection limit (table 2). As expected, the majority of the constituents were detected in nearly every sample; 15 of the 22 were detected in at least 90 percent of the samples. In contrast, lead was detected relatively infrequently, being found in only 4 of 30 samples. Antimony, beryllium, and uranium were not detected.

PRIORITY POLLUTANTS

The U.S. EPA publishes a list of 126 pollutants that are given high priority in water-quality monitoring and abatement programs (U. S. Environ-mental Protection Agency, 1994). This list of priority pollutants includes 15 trace elements, 10 of which were analyzed for this study. All 10 of the priority pollutants were detected in Asiatic clams and 9 of the 10 were detected in redbreast sunfish livers. Only silver was not detected in redbreast sunfish livers (table 2).

Although the priority pollutants were commonly detected, none were present in concentrations that were excessively high. None exceeded the risk-based screening values for the general public calculated by Cunningham and others (1992) for the APES Program (table 3). Only five of the priority pollutants were detected in concentrations that exceeded the NCBP 85th percentile for whole fish (Schmitt and Brumbaugh, 1990). The constituents that exceeded the NCBP 85th percentile were arsenic (2 Asiatic clam samples), cadmium (19 clam and 9 redbreast sunfish samples), copper (20 clam and 10 redbreast sunfish samples), mercury (3 clam and 2 fish samples), and selenium (8 redbreast sunfish samples) (table 3).

Although 28 of 30 cadmium samples and all 30 copper samples exceeded the NCBP 85th percentile, concentrations observed in Asiatic-clam samples were very similar or smaller than concentrations found in Asiatic clams from other NAWQA study areas in the southeastern United

States (fig. 2). This result indicates that concentrations in Asiatic clams higher than the NCBP 85th percentile might be relatively common in the Southeast. The frequency with which the NCBP 85th percentile was exceeded indicates that Asiatic clams and redbreast sunfish livers might accumulate these constituents more readily than whole fish. Thus, the concentrations we observed in Asiatic clams and redbreast sunfish livers are probably not indicative of a high level of contamination.

Most of the priority pollutants were detected with similar frequency in Asiatic clams and redbreast sunfish (table 2). This was not the case, however, for silver and arsenic. Silver was detected in 7 of 20 Asiatic clam samples but was not detected in any of the 10 redbreast sunfish samples. The difference for arsenic was even more striking. Arsenic was detected in all 20 Asiatic clam samples but was not detected in any of the redbreast sunfish samples (table 2).

These differences in detection frequency cannot be attributed to between-species differences in analytical detection limits. The detection limit for silver and arsenic in redbreast sunfish livers was always less than the concentrations observed in Asiatic clams. The data also indicate that differences in detection frequency also are probably not attributable to site-specific differences. At the five sites where both Asiatic clams and redbreast sunfish were sampled, silver was detected in Asiatic clams from three of the sites but was not detected in redbreast sunfish collected at the same sites. Similarly, arsenic was detected in Asiatic clams collected at all five sites but was not detected in redbreast sunfish.

Mercury

Mercury is a U.S. EPA priority pollutant that is of great concern in many parts of the United States. Fish-consumption advisories that are intended to protect the public from the toxic effects of mercury have been issued by 34 States and Territories (U.S. Environmental Protection Agency, 1995). Advisories are in effect for three water bodies in North Carolina, including the entire Cape Fear River Basin.

MERCURY–BACKGROUND

Methylmercury is the toxic form of mercury. It is formed by naturally occurring bacteria that convert inorganic mercury to methylmercury as a byproduct of respiration (Gilmore, 1995). Methylmercury is a neurotoxin that affects the central nervous system and can be extremely dangerous when it is ingested in high doses. For humans, exposure to toxic doses of methylmercury can cause short-term neurologic symptoms and even permanent brain damage. In general, the younger the individual, the more severe the damage caused by a particular exposure (White and others, 1995).

Methylmercury bioconcentrates and biomagnifies. Bioconcentration means that methylmercury concentrations often are much greater in aquatic organisms than in the water in which they live. Biomagnification means that concentrations are greater in predatory fish-eating species than in their prey. Studies have shown that the effects of bioconcentration and biomagnification can result in concentrations of methylmercury in fish tissues thousands of times greater than in the water in which they live (Bloom, 1995).

When laboratories analyze mercury in tissues, they usually determine the concentration of total elemental mercury, which includes both inorganic mercury and methylmercury. This is simpler and less expensive than analyzing methylmercury itself. Studies have shown, however, that 90 - 95 percent of the total mercury in fish muscle tissue is present in the form of methylmercury. The remaining 5 - 10 percent usually is in the form of inorganic mercury. Because the vast majority of mercury in fish muscle tissue is methylmercury, it is generally assumed that an analysis of total mercury is roughly equivalent to an analysis of methylmercury.

Table 2. Occurrence of U.S. EPA trace element priority pollutants and other trace elements in Asiatic clams (*Corbicula fluminea*) soft tissues and Redbreast sunfish (*Lepomis auritus*) livers collected in the Albemarle-Pamlico Study Unit, 1992-93
[U.S. EPA, U. S. Environmental Protection Agency; ---, no data]

Trace element	Asiatic clam: Number of detections/ total number of samples	Asiatic clam: Range of detected concentrations (micrograms per gram wet weight)	Redbreast sunfish: Number of detections/ total number of samples	Redbreast sunfish: Range of detected concentrations (micrograms per gram wet weight)
U.S. EPA trace element priority pollutants				
Arsenic	20/20	0.12 - 1.04	1/10	0.06
Cadmium	19/20	0.08 - 0.28	9/10	0.12 - 1.68
Chromium	20/20	0.09 - 0.34	10/10	0.13 - 0.34
Copper	20/20	2.33 - 5.86	10/10	1.79 - 130.82
Lead	3/20	0.05 - 0.11	1/10	0.11
Mercury	19/20	0.02 - 0.22	10/10	0.02 - 0.33
Nickel	20/20	0.06 - 0.17	7/10	0.05 - 0.25
Selenium	19/20	0.12 - 0.38	8/10	1.00 - 1.66
Silver	7/20	0.06 - 0.46	0/10	---
Zinc	20/20	12.64 - 25.85	10/10	14.91 - 24.65
Other trace elements				
Aluminum	20/20	1.50 - 35.84	10/10	0.26 - 4.86
Antimony	0/20	---	0/10	---
Barium	20/20	0.81 - 2.85	9/10	0.02 - 0.07
Beryllium	0/20	---	0/10	---
Boron	20/20	0.09 - 0.48	10/10	0.09 - 0.46
Cobalt	20/20	0.07 - 0.39	10/10	0.18 - 0.47
Iron	20/20	19.40 - 59.85	10/10	107.31 - 208.24
Manganese	20/20	0.89 - 5.45	10/10	0.98 - 2.35
Molybdenum	20/20	0.06 - 0.16	10/10	0.18 - 0.34
Strontium	20/20	0.40 - 1.60	10/10	0.11 - 0.36
Uranium	0/20	---	0/10	---
Vanadium	5/20	0.06 - 0.07	8/10	0.21 - 0.70

Mercury was detected in 29 of the 30 tissue samples; it was found in 19 of 20 Asiatic clam samples and in all 10 of the redbreast sunfish liver samples (table 2). Mercury concentrations detected in Asiatic clams ranged from 0.02 to 0.22 micrograms per gram wet weight (µg/g wet) (fig. 3; table 2) Mercury concentrations in redbreast sunfish livers were very similar, ranging from 0.02 to 0.33 µg/g wet weight (fig. 3; table 2). The four highest concentrations of mercury were observed in samples collected from the Blackwater River near Franklin, Virginia (fig. 1, site 2). At that site, three Asiatic clam samples had mercury concentrations ranging from 0.19 to 0.22 µg/g wet weight and a redbreast sunfish sample had a concentration of 0.33 µg/g wet weight. The fifth highest mercury concentration was observed in redbreast sunfish livers (0.18 µg/g wet weight) collected from Contentnea Creek near Hookerton, North Carolina (fig. 1, site 15).

The Blackwater River and Contentnea Creek are large integrator basins located almost entirely within the Coastal Plain. Both rivers have many swampy areas bordering them that contribute water stained with naturally occurring organic acids that give the water a dark "blackwater" or tea-like appearance.

Large mercury concentrations in fish are associated with blackwater rivers and lakes in many different areas of the United States. Studies have indicated that waters with low pH and large dissolved carbon concentrations, such as the Blackwater River, promote transformation of inorganic mercury to toxic methylmercury (Gilmore, 1995). The methylmercury is then available for uptake by aquatic organisms. The Blackwater River has the largest median dissolved organic carbon concentration of any of the NAWQA fixed water-quality sites where tissues were sampled. Many Coastal Plain streams and lakes in North Carolina and Virginia have similar water chemistry and thus may be particularly susceptible to mercury bioaccumulation.

Although mercury was commonly detected in tissues, it was present in relatively small to moderate concentrations. Mercury concentrations in Asiatic clams collected for this study are similar to concentrations in Asiatic clams collected in other NAWQA study units in the southeastern United States (fig. 2). None of the samples, including those from the Blackwater River and Contentnea Creek, exceeded either the FDA action limit for mercury (1.0 µg/g) or the risk-based screening value for the general public (3.2 µg/g) (Cunningham and others, 1992). Only the samples from the Blackwater river and Contentnea Creek exceeded the NCBP 85th percentile (Schmitt and Brumbaugh, 1990). It is noted, however, that the organisms analyzed for this study are relatively short-lived; organisms that are longer-lived would be expected to have higher mercury concentrations.

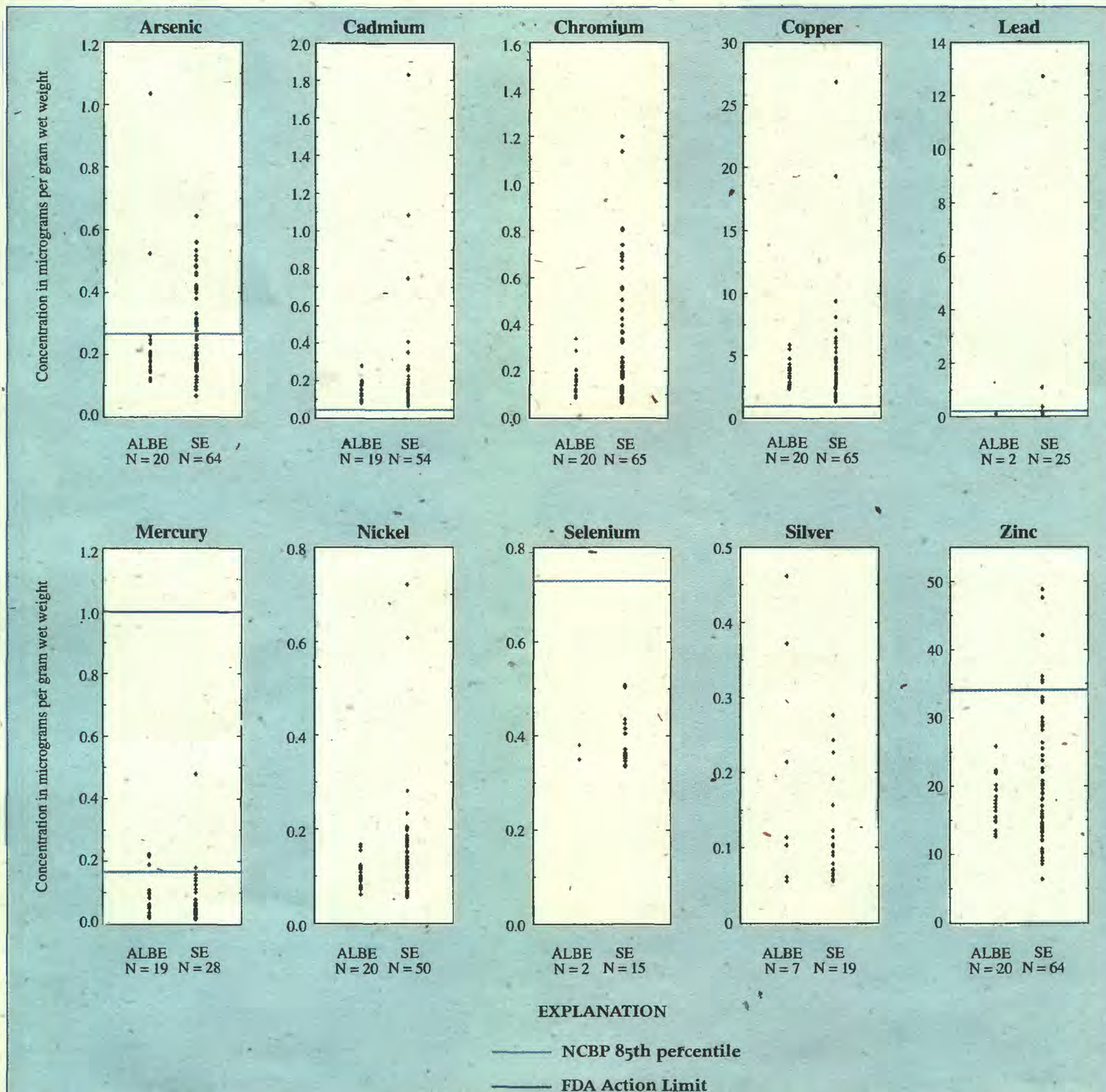


FIGURE 2. CONCENTRATIONS OF U.S. EPA PRIORITY POLLUTANTS IN SOFT TISSUES OF ASIATIC CLAMS COLLECTED IN THE ALBEMARLE-PAMLICO (ALBE) NAWQA STUDY UNIT AND IN OTHER NAWQA STUDY UNITS IN THE SOUTHEASTERN (SE) UNITED STATES. (ONLY VALUES GREATER THAN THE MAXIMUM DETECTION LIMIT FOR BOTH DATA SETS ARE SHOWN. NCBP IS U.S. FISH AND WILDLIFE SERVICE NATIONAL CONTAMINANT BIOMONITORING PROGRAM; FDA IS FOOD AND DRUG ADMINISTRATION.)

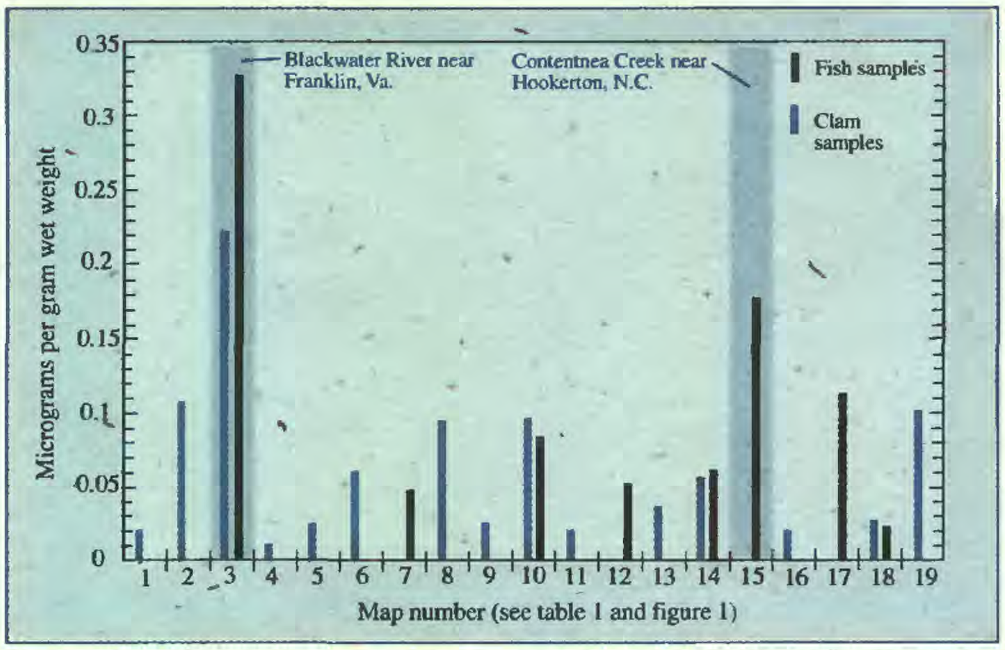


FIGURE 3. CONCENTRATIONS OF MERCURY IN SOFT TISSUES OF ASIATIC CLAMS AND IN REDBREAST SUNFISH LIVERS.

SUMMARY AND CONCLUSIONS

During 1992-93, a total of 30 tissue samples for trace elements were collected from 19 sites in the Albemarle-Pamlico NAWQA study area (fig. 1; table 1). In 1992, a total of 20 Asiatic clam samples were collected from 15 different sites, and in 1993 a total of 10 redbreast sunfish samples were collected at 9 sites. Analyses showed that of the 22 trace elements analyzed, 19 were present in concentrations above the analytical limit of detection (table 2). Only antimony, beryllium, and uranium were not detected. Mercury was detected in 29 of 30 samples collected; it was found in 19 of 20 Asiatic clam samples but in all 10 of the redbreast sunfish liver samples.

All 10 of the U.S. EPA priority pollutants that were analyzed were detected in Asiatic clams and 9 of the 10 were detected in redbreast sunfish livers. Only silver was not detected in redbreast sunfish livers (table 2). Lead was rarely detected, being found in only 4 of 30 tissue samples (table 2). Asiatic clams appear to be better bioindicators for silver and arsenic contamination. Silver was detected in 7 of 20 Asiatic clam samples and in none of the redbreast sunfish samples. Arsenic was detected in all 20 Asiatic clam samples but was not detected in redbreast sunfish livers. None of the samples had concentrations of priority pollutants that exceeded risk-based screening values for the general population (table 3). Although 28 of 30 cadmium samples and all 30 copper samples exceeded the NCBP 85th percentile, concentrations in Asiatic clams observed in this study are similar to concentrations found in other NAWQA study areas in the southeastern United States (fig. 2).

The highest concentrations of mercury were observed in samples collected from the Blackwater River near Franklin, Virginia. Although mercury was commonly detected in tissues, it was present in relatively low to moderate concentrations. None of the samples, including those from the Blackwater River, exceeded either the FDA action limit (1.0 µg/g) or the risk-based screening value for the general public (3.2 µg/g). Although this study showed that none of the priority pollutants were detected at concentrations that would indicate an immediate threat to human health, the widespread occurrence of mercury and the occurrence and concentration of many of the other trace elements may warrant further investigation and monitoring.

TABLE 3. RISK-BASED SCREENING VALUES FOR THE GENERAL PUBLIC AND 1984 NCBP 85TH PERCENTILE FOR WHOLE-FISH TISSUES [USEPA, U. S. ENVIRONMENTAL PROTECTION AGENCY; NCBP, NATIONAL CONTAMINANT BIOMONITORING PROGRAM; n, TOTAL NUMBER OF SAMPLES; ---, NO DATA]

U.S. EPA trace-element priority pollutant	Species having maximum concentration	Maximum concentration detected (micrograms per gram wet weight)	Risk-based [1] screening value for the general public	NCBP 85th [2] percentile (micrograms per gram wet weight)	Number of samples exceeding NCBP 85th percentile	
					Asiatic clam n=20	Redbreast sunfish n=10
Arsenic		1.04	3.2	0.27	2	0
Cadmium		1.68	11	0.05	19	9
Chromium		0.34	54	---	---	---
Copper		130.82	431	1.00	20	10
Lead		0.11	4.6	0.22	0	0
Mercury		0.33	3.2	0.17	3	2
Nickel		0.25	221	---	---	---
Selenium		1.66	54	0.73	0	8
Silver		0.46	---	---	---	---
Zinc		25.85	2,154	34.2	0	0

[1]Cunningham and others, 1992
[2]Schmitt and others, 1990

For additional information, contact the following:

For Albemarle-Pamlico NAWQA
Chief, Albemarle-Pamlico NAWQA
U.S. Geological Survey
3916 Sunset Ridge Road
Raleigh, NC 27607,
Phone 919-571-4000

For National NAWQA
Deputy Assistant Chief Hydrologist
National Water-Quality Assessment Program.
U.S. Geological Survey, National Center, MS 413
Reston, VA 22092.
Phone 703-648-5716

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J. CARAS, ILLUSTRATOR